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A REVISED SURVEY OF

THE FOREST TYPES OF INDIA

BY

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सत्यमेव जयते

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2	16–17	*(Schima Bauhinia)*	*(Schima-Bauhinia)*
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153	16	*C. nardus*	*Cymbopogon nardus*
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203	28	moisture	moister
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251	33	unknowr	unknown
267	11	*(roxburghii)*	*(Pinus roxburghii)*
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294	11	broken	brakes
309	5	profilic	prolific
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PREFACE TO THE REVISED SURVEY

Over a quarter of a century has passed since "A Preliminary Survey of the Forest Types of India and Burma" was published. In the penultimate paragraph of the Prefatory Note it was stated that "The classification is published with the definite object of calling forth constructive criticisms which will enable someone to revise and complete the much needed survey as soon as possible; if it succeeds in eliciting this criticism, it will have served its purpose".

The Preliminary Survey was for a long time out of print and latterly impossible to obtain until it was re-printed in 1962. Proposals for revision have been put forward from time to time (1951, 1956) but the necessity for a background of knowledge covering the whole country, the very magnitude of the task, and the competition of other urgent work have resulted in the long delay. In 1961/62, however, the senior author was offered an assignment with the Indian Government under the Colombo Plan for the purpose of undertaking this revision [together with that of the *Manual of Silviculture for India* (1933)]. The essential first step was to make a comprehensive tour of the country to discuss suggested additions and amendments with the local interested foresters and botanists, as far as possible in the types under discussion. This tour was undertaken between 2nd November, 1961 and 10th June, 1962 with the fullest co-operation of all the State Forest Departments concerned. All sixteen States (also the Andamans and one corner of N. E. F. A.) were visited for one to two weeks each. The time in each State was far too short to visit or revisit all the places it was desirable to include, but with modern facilities notably air and jeep travel, it proved possible to include the majority. The tour finished in Kashmir which was not covered in the Preliminary Survey. As a result, it has been possible to cancel a good many of the endorsements "NOT SEEN", but the extension of the area to be covered to include the whole of the present Union, has brought in new areas, e.g. Manipur, that have to be given the endorsement.

The junior author was unfortunately not able to join this special tour but having been Central Silviculturist for more than five years, had already seen a wide range of types. He also remained responsible for his official duties as Conservator for Working Plans and Research in Uttar

Pradesh but was able to devote about 4½ months, from September 1962 to January 1963, exclusively to the revision of the Types and the Manual of Silviculture, as Officer on Special Duty at the Forest Research Institute.

The whole of this revision is the joint work of the two authors, but the senior author gave primary attention to the wet tropical forests and the hill forests, whilst the junior author was in the first place concerned with the moist and dry tropical forests including the important teak, sal and bamboo forests.

Difficulties arise in connection with the botanical nomenclature to be followed in a work such as this. The policy adopted has been to use the modern names [following BOR (1953, 1960) and RAIZADA (1958, 1959) for the most part] wherever the identity is not in question, e.g. *Salmalia* instead of *Bombax*, even where this involves changing the name used by the author being quoted. On the other hand, where questions of identification are involved, we have retained the author's nomenclature. To facilitate correlation of the current and obsolete names a list of synonyms has been included as an appendix.

Special attention has been given to criticisms made in reviews of the Preliminary Survey published soon after its appearance. E. O. S. made several valuable suggestions which have been taken up. A useful review by BOURNE who had special knowledge of the South Indian forests [*Forestry*, X(2), 1936] stressed that in his opinion, several of the types differentiated as climatic or edaphic climaxes were only seral in status. This possibility was mentioned in the original and it has now been reconsidered, though it is felt that BOURNE has gone too far in the other direction. He also suggested that the poly-climax theory would fit the facts better than the mono-climax theory that was actually followed, mainly for the reason that it was more convenient in presentation. Questions of the use of terms are involved and the authors, whilst continuing the earlier practice have an open mind on this point although inclining to the view that the climatic and vegetational gradient theory is the most rational approach to the problem. Degradation stages have been differentiated from secondary seres and additional notes given on ecological status.

Attention was called to the inadequacy of information on the sub-tropical types known or suspected to exist on the higher hills in several parts of the country, apart from the Himalayas, the Nilgiri Hills and the hills of Assam. Accounts of the vegetation of several of these sites have since been published and some of them have been visited by the present authors. Whereas a quite considerable amount of attention has been given to the floristics of areas of special interest such as the tops of the hills, the focus has been on plant geography rather than ecology. Most of the published accounts are of little value for the present purpose as there is no indication of the contribution made by the individual species to the plant community as a whole. It remains true that they are relatively unimportant from the forestry point of view, but they are retained in the Survey for their general interest.

At the Fourth World Forestry Congress, SUKACHEV (1954) contributed a paper on the importance of recognition of forest types for forestry practice, emphasising his view that the whole complex of life forms and their environment (*biogeocoenosis*) should form the basis of study and classification. The Congress recommended his proposals to the International Union of Forest Research Organizations for study (SUKACHEV 1958) with a view to wider application but hitherto no developments affecting the present position in India have been notified.

PURI has recently (1960) brought together most of the information that has been published on Indian forest ecology, and his two large volumes may well be the easiest source for reference to many of the works quoted here. He has however left it to the reader to make his own critical evaluation and synthesis of the mass of data presented (over 560 references are quoted), and this is a matter of considerable difficulty for the practising forester. A great deal of the same literature is incorporated in the present monograph but it has been done from a different point of view and with a different objective. Our primary purpose has been to provide the forester with as simple an overall view and summary as possible; we may well have erred on the side of over-simplification.

Reference must also be made to SCHWEINFURTH's 1957 publication on "The horizontal and vertical distribution of vegetation in the Himalaya" as he has not only given detailed descriptions of the twelve geographical regions into which he differentiates the mountain range but has drawn up a list of 29 vegetation types, 23 of which occur in the Union of India: biotic influences are also considered for each type.

The distribution map has been redrawn after amendment on comparison with maps submitted from the several States. Owing to the small scale it inevitably remains mainly diagrammatic. The climatic map has also been revised with the incorporation of more recent data. A soil map of India and some additional maps have also been included for the sake of completeness.

The detailed climatic data have been amended and extended in accordance with the later information now available in the records published by the Meteorological Office. They have also been converted to the metric system.

Analytical data on soils representing the main soil groups differentiated in India as well as the main forest types recognized in the Revised Survey have also been given in an appendix.

The majority of the original illustrations of Indian forest types have been retained, but some replacements and many additions have been made where suitable photographs were available in the photographic collection of the Forest Research Institute. Acknowledgement is made on each plate concerned.

Finally, since the classification adopted in the Preliminary Survey has been largely used for describing forests in Working Plans which will continue to be in force for years to come, it has been considered desirable to include a table of concordance for types recognised in the Preliminary and the Revised Surveys.

In conclusion, it must be stated that although this revision should be a considerable improvement on the Preliminary Survey in factual information and theoretical treatment, there has been much less detailed study and consequent advance in knowledge and understanding of the forest types of the country than could have been hoped for in the considerable period that has lapsed. It is the hope of the authors that a renewed call for constructive criticism and purposeful field studies will find a wide response.

The authors take this opportunity of thanking all the Forest Officers of various States and the officers of the Divisions of Forestry and Forest Botany, Forest Research Institute, for all the help rendered but for which the revision could not have been completed so expeditiously.

H. G. CHAMPION,
Silviculturist, Forest Research Institute
1925-37.

December 1962

S. K. SETH,
Silviculturist, Forest Research Institute
1955-61.

PREFATORY NOTE

This compilation has been produced under several difficulties. The need of a standard classification for the important forest types of India has long been felt in connection with silvicultural work particularly in its application to forest management under working plans, and this need has led to the adoption of local standard types in some provinces. The same need was stressed at the 1929 Silvicultural Conference at Dehra Dun in connection with the study of the group of types included under the term "tropical evergreen". So in 1929, I asked Provincial Silviculturists to collect views on the subject held in their province and forward them to me for compilation. Lists with very varying amount of detail were received from all provinces during 1930 but owing to the complexity of the subject, my repeated absence on tour, and preoccupation with other problems, it has only recently been possible for me to finish work on this subject. The survey now completed has revealed the lacunae in the recorded information, some of which could doubtless be filled up were it possible to keep publication pending yet another year, a source which it has been decided for a variety of reasons not to adopt.

In addition to these lists, I have utilised all the published information I could trace, particularly the introductory pages of Troup's "*Silviculture of Indian Trees*" and Stamp's "*Vegetation of Burma*", but most of all my own observations and filled notes made in all parts of India during the past 20 years. Although I have been fortunate enough to have been able to see, even if in some cases only from the railway carriage window, nearly all the types described in the following pages, it has often been impossible for me to make detailed studies, and I have made use of what seemed to me the most suitable accounts and lists for the purpose in hand, irrespective of their source. Types which I have not seen at all, I have indicated at the head of the accounts of them, and these accounts are accordingly entirely compilations of information from the available sources.

Working Plans generally include a description of the forest types they are concerned with and give lists of the characteristic plants of each. I have not thought it necessary to include references to all of these in the list of references, though I have freely utilised them. The source of the lists of species taken from these and other published works is indicated in each case, the absence of mention of the authority implying that the list is from my own notes or compiled from several sources including my own records.

The problems of identification and nomenclature of the trees and plants mentioned have been difficult to deal with. Particularly in the case of the shrubs, etc., some mistaken identifications are undoubtedly included, and where I have reason for doubt I have sometimes substituted "sp." for the doubtful specific name. On the whole, this is however not an important matter, as the mistakes are unlikely to be misleading and attention will doubtless be drawn to them permitting of correction in a later revision. Problems of synonymy result in the same plant appearing in different lists under different names, but I have hesitated to make changes when quoting from others.

The account of the Peninsular and Burma subtropical forest types is outstandingly incomplete, and it may be considered advisable to drop them out when this pioneer effort is revised. One of the chief reasons is their relative unimportance in forest management and their restricted occurrence.

The blocks of the illustrations used in this Record were prepared more than a year before the letterpress reached its final form and so, in a few instances, the name of the type on the plate does not exactly agree with the name used in the letterpress; the latter is to be taken as the one recommended.

The courtesy of several officers who have allowed me the use of their photographs is gratefully acknowledged, Mr. A. E. Osmaston in particular having provided me with four excellent illustrations.

This classification is put forward as the best I can do at present from my personal acquaintance with the forests of India and Burma with the help of the published literature and the provincial lists referred to. I am only too aware that it is open to all manner of criticisms, both as regards what is given and what is omitted. The classification is published with the definite object of calling forth constructive criticisms which will enable some one to revise and complete the much needed survey as soon as possible; if it succeeds in eliciting this criticism, it will have served its purpose.

I wish here to acknowledge, with many thanks, the frequent help given me by Mr. C. E. Parkinson, Forest Botanist of the Forest Research Institute, particularly in reading through the final typescript; also the help received from the Provincial Silviculturists.

H. G. CHAMPION,
Silviculturist,
Forest Research Institute

15th April, 1935.

GLOSSARY OF VERNACULAR NAMES AND TERMS

Babul	Acacia arabica.
Blue pine	Pinus wallichiana.
Chir pine	Pinus roxburghii.
Deodar	Cedrus deodara.
Khair	Acacia catechu.
Mulberry	Morus indica.
Oak	Quercus sp.
Sal	Shorea robusta.
Silver fir	Abies pindrow.
Semal	Salmalia malabarica.
Sissu	Dalbergia sissoo.
Spruce	Picea smithiana.
Teak	Tectona grandis.
Bhabar	Deep, dry boulder deposits (max. width 21 km. in U.P.; 365 m. at base of hills sloping down to 240 m. at the outer limit) skirting the base of outermost Himalayan hills.
Damar	Elevated river terraces, generally consisting of boulder deposits overlain by more or less deep porous loam, flat or slightly sloping, along the chief river valleys (45 to 60 m. above the level of the stream). Also locally (*thaplas*) at the base of the outer Himalayan or Siwalik hills.
Dun	Broad elevated valley (cir. 600 m.) within the outer ranges of the Himalayan and Siwalik hills. The best known is *Dehra Dun* lying between the Siwalik hills and the Himalayas proper.
Tarai	Swampy belt below the *bhabar* (max. width 13 km. in U.P., sloping gently from 240 m. to 200 m. at outer limit). (Underground streams flowing through the *bhabar* deposits emerge as springs at the commencement of the *tarai*).

ABBREVIATIONS

The following floristic groups have been usually differentiated :

I — Top canopy trees.
II — Second storey trees.
IIa — Bamboos.
III — Shrubs.
IVa — Herbs.
IVb — Grasses.
V — Climbers.
Epi. — Epiphytes.
Par. — Parasites.

*Against a plant name implies that the species is particularly characteristic of the type. The following abbreviations have been used :

E — Evergreen.
D — Deciduous.
(va) — very abundant.
(a) — abundant.
(f) — frequent.
(c) — common.
(o) — occasional.
(r) — rare.
(la) — locally abundant.
(lc) — locally common.
S.P. — Sample Plot.
P.P. — Preservation Plot.
L.I.P. — Linear Increment Plot.

CHAPTER I

INTRODUCTORY

Reasons for classification

The need for classification of material for the understanding of inter-relationships and fundamental principles involved is recognized in all branches of science. In an applied science such as forestry, this need is emphasized by the general experience that most of the techniques devised for directing or controlling the development of a forest are only applicable within a limited range of conditions and forest "type". It therefore becomes important that a classification should be available as a standard of reference for research workers and practitioners, both to facilitate application of advances in knowledge and to minimize waste from wrong application. The extent to which the provisional classification here under revision has been used is in itself an acknowledgement of this need.

Definition of "Forest Type"

For the purpose of this memoir a forest type may be defined as a unit of vegetation which possesses (broad) characteristics in physiognomy and structure sufficiently pronounced to permit of its differentiation from other such units. This is irrespective of physiographic, edaphic or biotic factors. It is selected in the first place subjectively from the ever-varying cover of vegetation, with boundaries arbitrarily imposed on what are in fact gradual changes (clines or continua). Since these forest types have a bearing on the practice of scientific forestry, and practical utility is indeed the main reason for distinguishing them, necessarily greater importance is placed on the main tree layers or on the most emergent vegetation. Distinctions based on shrub and ground flora, characteristic of much recent ecological work on the vegetation of India, have necessarily been given a subordinate place.

The major type-groups are subdivided into types on a geographic basis since a recognizable type-group varies somewhat with locality owing to differences in floristics and minor variations in climate and site occurring within the range associated with each group-type as a whole.

Units which are clearly associated with a definite site factor and differ appreciably from the prevalent type of the surrounding area are referred to as *edaphic types* (E). In using this term no exclusive emphasis is intended on the special physical or chemical properties of the soil mantle as such ; on the other hand it is felt that the sum of the distinctive features of the site whether caused in the main by micro-topographic, micro-climatic or moisture and drainage factors, affect the vegetation to an extent rendering it advisable to differentiate it from the typical form believed to be primarily determined by climatic factors. One easily recognized group of such types, those occurring in permanently or periodically wet sites, are separately treated as SWAMP TYPES (to which is appended, for convenience only, the littoral forest type occurring on coastal beaches).

In giving names to types, terms implying site conditions have been avoided as far as possible, but to avoid circumlocution or the use of words too long or technical for general convenience, the qualifications *wet*, *moist* and *dry* have been admitted, implying that the vegetation has the appearance commonly associated with different degrees of moisture availability.

Similarly, taxonomic terms have been excluded from the name of types wherever possible, but as most authors have found, certain species or higher taxads, such as bamboos, palms or pines, have a characteristic form which they impose on the communities which they dominate, and we lack a simple morphological term which might be substituted for the taxonomic one.

The same principle has been followed in naming subtypes and lower ranks, but the family, genus or even the specific name of conspicuous dominants has been more freely used, e.g. *Mesua* forest, pine forest and even *ban* oak forest. In a few cases, where the subtype differentiated appears to be the same as, or closely to resemble, the ecologist's 'association', the practice of designating it by two or more dominant genera has been followed, though usually only as a sub-title,c.g. Submontane semi-evergreen forest (*Schima Bauhinia*). As an example of the existing diversity of nomenclature may be quoted a generally recognized forest type variously described as the *Laurus-Melia* hylium (though neither genus occurs in it despite predominance of *Lauraceae* and *Meliaceae*), the *Cinnamomum-Amoora* association, Mixed evergreen forest, and Assam valley semi-evergreen formation. We are proposing to name this as a Sub-Himalayan subtype of the Tropical semi-evergreen forests.

It has to be emphasized that in the big majority of cases, especially those of a climax status, there are no sharp boundaries between adjoining types. There is normally a transition zone or ecotone (see Plate 70) which may be of any width and is sometimes quite extensive. This is evidently intimately linked with the sharpness or otherwise of changes in the complex of factors, climatic, edaphic, physiographic or biotic, which determine the occurrence of the type. In practice, there is a natural tendency to delimit types in a given area in such a way as to allocate as small a proportion of the gross area as possible to transitional status. As the same transition of site factors and vegetation may elsewhere be widely drawn out, perhaps at the expense of the conditions and vegetation selected as a type, the method is illogical and may render comparison with other areas impossible, but it has such advantage in local land use practice that it is generally adopted in forestry and agriculture.

Collection of data for classification of types

DANSEREAU (1951) has developed an elaborate method of recording the features of vegetation using a variety of symbols. The use of such methods facilitates comparisons and mapping.

The very useful technique of the Profile Diagram introduced by RICHARDS (1933) has been widely adopted. Its limitations are the initially subjective choice of the small sample and the demands it makes on time though this can be reduced with some loss of precision by making the necessary observations and measurements from the ground. A still very useful method of recording the necessary data was published in 1939 by RICHARDS, TANSLEY and WATT.

Criteria for classification of forest types

It should first be noted that a classification of vegetation may be needed for several different purposes and the most suitable and convenient classification will vary with the purpose. Thus big scale mapping and small scale mapping have different requirements, whilst general land use planning and forest management planning require different approaches. The purely scientific study of vegetation whether static or dynamic again calls for other methods.

It will be agreed that any classification should be as objective as possible, independent of speculation as to past history or future development. Correlations should be observed but not accepted as causal without adequate evidence.

There are two main approaches to classification of vegetation, *viz.*, the breaking down of the existing complex into successively smaller categories, and the building up from the smallest recognizable units into successively higher ranks. The latter method is very familiar in the standard taxonomic classification of plants from species to genera, to families and still wider groups. However, in applying this method to plant communities there at once arises the difficulty of finding a basic unit as definite and definable as a species. The method has, however, been adopted by the Braun-Blanquet school of ecologists and has a wide vogue in the temperate zone where the flora is simple as compared with the tropics and is well known, and where moreover, for historical reasons, habitats and communities are usually more sharply delimited. By general agreement, although plant communities such as *associations* can often be differentiated after close study of a limited area of tropical forest, our knowledge is far too incomplete to make this method generally applicable at present. This method has, however, been used by BEARD (1944, 1955) in his classification of tropical vegetation.

Plant association

The ecologists' basic unit for plant communities, the association, has been defined as "the largest floristic unit consisting of a definite assemblage of species (usually with definite dominants) and a definite habitat" and as being characterized by its definite floristic composition, life form, structure and habitat (after TANSLEY and CHIPP, 1926). Alternatively it has been defined (BURTT-DAVY, 1938) as a community of definite floristic composition within a formation—which latter is defined on physiognomy not on floristics. The associations of temperate forests tend to be dominated by a few or only one species (consociations) whereas tropical forests with their richer flora, above all in the moister more luxuriant types, typically have mixed associations with many dominants all seemingly equally adapted to the site. The "types" differentiated in this monograph agree with the 'formations' of most ecological writers. The first breakdown is mostly to geographical subdivisions of the formation. Some of the subtypes ultimately described have the status of associations whilst other are undoubtedly groups of associations not yet studied in enough detail for further analysis. In the montane types, conditions approach those of the northern temperate forests so that they can be described in the same way in terms of associations of one or few dominants with the well established subsidiary floristic units of societies etc.

The alternative method presents one with the problem as to the criteria to be used in dividing up the vast range of forms of vegetation that is met with. An excellent review of the possibilities has been put forward by FOSBERG (1958) taking into account the proposals of BURTT-DAVY (1938) and BEARD (1944), as well as those of the pioneers beginning with SCHIMPER (1905), MAYR (1909) and RUEBEL (1930). The possible bases for classification are at least seven, *viz.*, (1) Physiognomy, (2) Structure, (3) Function, (4) Floristics, (5) Dynamics, (6) Environment and (7) History. By "function" is meant here the morphological characteristics which seem to indicate adjustment to environment. Practical difficulties arise in attempts to draw up a scheme based on only one of these aspects, though apparent inconsistencies are often traceable to nomenclature as mentioned above in connection with the naming of types.

Physiognomy provides an easy basis for a rough differentiation of very broad categories and has been used to some extent by most writers including SCHIMPER. It is ordinarily taken to include characters such as evergreen or deciduous habit and such structural or functional features as are associated with very dry (*xeromorphic*) or very wet (*hydromorphic*) sites.

Structure covers stratification, dimensions, especially height and spacing. FOSBERG uses spacing as his starting point, followed by height. RICHARDS and others give considerable prominence to the number of strata, though this is often difficult to determine conclusively.

Function as mentioned above is taken here to cover the common morphological characters of the species occurring together, some being evidently related to site conditions, e.g. RAUNKIAER's (1934) life forms. Buttressing, bark form, leaf size and cauliflory provide other examples. Combined with structure, this criterion has been most widely used by foresters.

Floristics.—The taxonomist tends to prefer this basis as most objective and definite, but apart from difficulties of identification, it obscures the relationships between the vegetation of different floristic regions. Opinion varies as to the use of the factors of composition such as frequency and constancy for defining or identifying types. However, floristic characters are useful for designation of subordinate units within a type, and are often used (as here) for the ultimate units of classification.

Dynamics.—It is generally admitted that all or nearly all vegetational types are always changing, even if only very slowly. Their presence and growth reacts on the soil and (at least) the microclimate and the reaction continues to be mutual. Even when an equilibrium appears to have been reached, it only applies to the community as a whole, not to individual parts of it. The use of this criterion involves the application of some part of the CLEMENTIAN (1916) theory of plant succession and vegetation climax. In general, it has been found necessary to differentiate types which are known or believed to have been considerably modified by biotic influences, and also those that are demonstrably changing within a moderate period of time (say measurable in decades). The relatively stable remainder are viewed as '*climax*' types, and it is unimportant for forestry purposes whether the climax condition is determined primarily by climate, or by site and climate combined. This should not be taken as necessarily implying an unreserved acceptance of the CLEMENTIAN concept of climax; on the other hand it should be taken to mean a discrete, and to some extent arbitrary, subdivision of the prevailing climax pattern (WHITTAKER, 1953) or continuum.

Habitat.—Whilst climatic and soil moisture factors are part of nearly all classifications, no classification has yet been put forward based solely on habitat factors. It would moreover appear unsound to erect a classification based entirely on factors other than those of the vegetation itself. In fact the use of both groups of criteria, those relating to the environment and those deduced from the nature of the vegetation would appear, to some extent, to be essential for the purpose of evolving a usable and practical classification. Since they are largely complementary, it is perhaps unnecessary 'purism' to attempt to exclude either of them from a functional classification. Climatologists and pedologists have thus often found it convenient to classify climate and soil in part on the vegetation associated with it, and there is no doubt that duly cautious acceptance of this association is useful in practice and greatly simplifies nomenclature. The nature of the soil and the reactions between it and the vegetation it supports, obviously play an important role, but except in the most pronounced cases such as limestone or quartzite, heavy clay or blown sand, are too complex and difficult to assess to be of great assistance. Though important in theory, it is immaterial in practice whether the soil itself is "mature" and in equilibrium with the climate or not, provided it and the vegetation are stable over the period of the time suggested.

A further point to be noted when climatic and other site factors are under consideration is that many of them are interrelated in such a way that a high level of one may counterbalance in its effects a low level of another; thus a more retentive soil or a lower temperature may compensate for greater aridity of general climate.

Physiography is patently important in the occurrence and distribution of forest types. The immediate effect is that of climate, and if climate differences are dominant then those (in temperature, rainfall, radiation and light) between a steep southern slope and a gentle northern slope, both at the same altitude, will be expected to determine the presence of the different forest types (alternes) associated with those different climatic regimes. In such cases, indeed, the vegetation is the best and usually the only obtainable indication of the climate.

History.—Whereas the history of a site and the vegetation on it are often of the greatest importance in determining its present condition and potentialities, so that it should always be ascertained as far as possible, it is so usually conjectural as to be inadmissible as the basis for objective classification.

CHAPTER II

FACTORS DETERMINING FOREST TYPES

The type of vegetation met with in a given locality depends on the climate, the soil and the past treatment, so that a study of these three factors is essential to an understanding of the variations encountered and the interrelationships of the types which it is found convenient to differentiate. These three main factors are far from being mutually independent, but they are better considered separately in the first place before their joint effects are examined. Topographical situation in respect of altitude, slope and aspect makes itself felt through its influence on local climate and soil.

(a) CLIMATE IN RELATION TO FOREST TYPE

TEMPERATURE is the most obvious factor of climate. It can be broadly related to latitude giving a rough differentiation into four zones :—

(1) *Tropical.*—Very hot and winterless.

(2) *Subtropical.*—Hot with a cool winter.

(3) *Temperate.*—With a warm summer and a pronounced winter.

(4) *Arctic.*—With a short summer and long severe winter.

It is however obvious that no hard and fast lines can be drawn, and that the relation of climate to latitude is so greatly influenced by other factors, mainly by the distribution of land and sea, by altitude, by prevailing winds and ocean currents and by their indirect effects, that it is necessary to substitute suitable temperature ranges for latitude to make such a classification of any practical value. It is also evident that no single temperature figure such as mean annual temperature will meet requirements, as temperature range must also be taken into account. Attempts to express numerically the temperature characteristics of a climate bring the realisation that the factors having the greatest influence are different at the two ends of the scale, so that at the colder end, the period during which the temperature is high enough to permit plant growth is of predominating importance, whilst at the hotter end, it may be the existence or extent of a period cool enough for growth to be stopped or slowed down. It is for this reason that the extensive European and N. American studies of the subject are of such limited value for India.

Examining the temperature data for India, for which the official *Climatological Atlas* and the *Climatological Tables of Observatories* in India summarise all that are essential, it is found that the mean annual temperature exceeds 24° C over the whole country with the exception of the hill areas and the extreme North-West. Variation with latitude is almost completely obscured by other factors, though in the Indo-Gangetic plain there is roughly a fall of 0·75° C for each 1° N Latitude. In striking contrast with the irregularity in mean annual temperature is the temperature distribution in the winter months, January being representative. The mean maximum isotherms then run very fairly directly East and West over the northern half of the country; the variation for 1° latitude being about 0·75° C. The 18° C isotherm for January roughly follows the Tropic of Cancer.

On this primary basis of temperature, India may be divided up as follows :

Zone	Mean annual temperature	Mean January temperature	Winter
I. Tropical	Over 24°C	Over 18°C	None ; no frost.
II. Subtropical	17° to 24°C	10° to 18°C	Definite but not severe; frost rare.
III. Temperate . . .	7° to 17°C	—1° to 10°C	Pronounced, with frost and some snow.
IV. Alpine	Under 7°C	Under —1°C	Severe, with much snow.

Such a classification will obviously result in certain localities falling in one zone on January temperature but in another on mean annual temperature; thus Jodhpur is subtropical on the former criterion and tropical on the latter. The vegetation itself will then indicate to which it more properly belongs.

Effect of altitude.—From the known relation between latitude and temperature, the upper altitudinal limits of the zones might be expected to fall considerably higher in Peninsular India than in the Himalayas, but for a variety of reasons this is not very noticeable. Thus a mean annual temperature of 17° C is experienced in the Nilgiri Hills at about 1,830 m., in the West Himalayas at about 1,700 m., and in Assam at 1,500 m. The corresponding figures for a January temperature of 10° C are : Nilgiris—2,150 m., West Himalayas—1,600 m. and Assam—1,500 m. The extremely small range of the monthly means in the Nilgiris (12·5° to 15·7° C only) is of course an influential factor in this connection. The subtropical zone should take in the great Indo-Gangetic plain running up over the plateaux and lower hills; it should be divisible in a general way into warmer lowland and cooler hill sub-zones, but in India the former has so much in common with the tropical as to render joint consideration a necessary course. The temperate and alpine zones are only met with in India in the higher hills.

The effect of altitude varies with conditions, a rise in the hills of 270 m. corresponding on the average to a fall of 1° C in mean temperature upto about 1,500 m. (BLANDFORD), above which the fall is more rapid. In general, this fall is also more pronounced on the lee side of hills than on the windward side; thus it is reported to be 1° C for 100 m. rise on the west side and 122 m. on the east side of the Nilgiris, and it may also be noted that towards the north, the rate of fall is much more rapid in summer than in winter perhaps 10 per cent above and below the mean respectively (this difference amounts to 20 per cent in Europe).

Ranges of temperature.—It does not appear that diurnal range has much effect on vegetation provided tolerable limits are not overstepped. The range over the country as a whole is about 10°C in January and July, but 20° C in April and October, increasing in a N.W. direction from the East Coast.

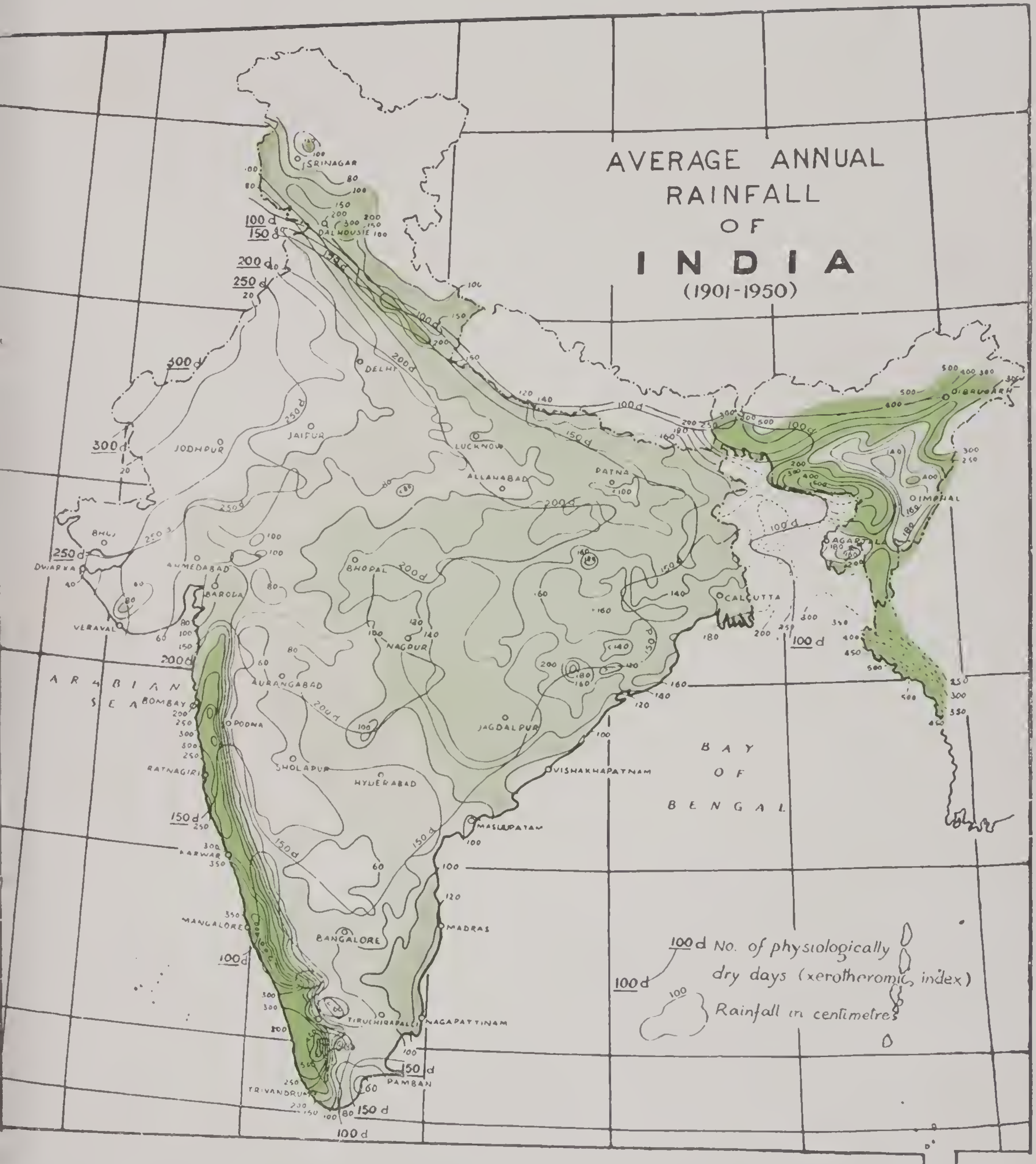
Extremes of temperature.—The maximum temperatures recorded appear never to reach a level critical for plant survival but the minimum is of undoubted importance. Few if any of the trees of the wet tropical forest can survive frost and the indications are that many tropical trees are weakened if not killed by low temperature not actually down to freezing. However, although trees and their regeneration may be killed back in part or to the ground (by exceptionally high or exceptionally low temperatures), this does not necessarily kill them out or even prevent their forming an important or even dominating part of the vegetation. Thus both sal and teak-bearing forests occur extensively in areas and on sites where they suffer periodically from frost. Although biotic factors may be involved, the principal adverse climatic factor is undoubtedly frost. Where the frost is a relatively shallow ground frost the sensitive regeneration may be protected by the overwood, provided it is dense enough, and conversely, clearings or heavy thinnings may result in frost incidence where formerly there was none.

It may be noted that killing frosts may only occur at long and irregular intervals as is well-known for sal in U. India, the cold weather of 1904/5 being notorious in this respect (OSMASTON, 1926).

Temperature cycles.—Analyses have been made by climatologists to see if any cyclic recurrences exist in temperature data, but no statistical basis for such an assumption has been found (PRAMANIK and JAGANNATHAN, 1953).

RAINFALL.—As regards total annual rainfall, India exhibits an extremely wide range of conditions from less than 150 mm. in the Thar desert to nearly 5,000 mm. locally in the Khasi hills of Assam. Precipitation over 2,500 mm. is met with in three different parts of the country, *viz.*, W. Ghats, N. Bengal and Assam, and locally in the W. Himalayas as at Dharmsala.

Total annual fall may be an important factor in determining the nature of the vegetation, but its seasonal distribution exerts an equally far-reaching influence. Except for the innermost parts of the Himalayan ranges and the North-West corner of the country where rain and snow brought by winter disturbances from the North-West contribute an important part of the total fall, practically the whole rainfall in India occurs during the summer to autumn monsoon period. This rainy season varies in duration with a general increase from N. W. to E. and S. E. so that Upper Assam experiences the shortest dry period and the North-West the longest. If months with less than 50 mm. average fall are considered to be dry, the first mentioned get 3 dry months and the last 9 or more dry months. The length of the dry season thus defined is indicated in Map 2.


AVERAGE ANNUAL RAINFALL OF INDIA (1901-1950)
100d No. of physiologically dry days (xerothermic index)
100 Rainfall in centimetres
ARABIAN SEA
BAY OF BENGAL
SRINAGAR
DALHOUSIE
DELHI
JAIPUR
JODHPUR
LUCKNOW
ALLAHABAD
PATNA
DIBRUGARH
IMPHAL
AGARTALA
CALCUTTA
BHUJ
DWARKA
AHMEDABAD
BARODA
VERAVAL
BHOPAL
NAGPUR
AURANGABAD
BOMBAY
POONA
JAGDALPUR
SHOLAPUR
HYDERABAD
VISHAKHAPATNAM
RATNAGIRI
MASULIPATAM
KARWAR
MANGALORE
BANGALORE
MADRAS
TIRUCHIRAPALLI
NAGAPATTINAM
PAMBAN
TRIVANDRUM

Within the monsoon period, there is one rather important variation in that the lower parts of the S.E. of the peninsula (on the Carnatic coast) get relatively little rain during the usual S.W. monsoon period from June to September, but most of their rainfall from the retreating or N.E. monsoon in October-November. This has resulted in the differentiation of a special type of evergreen vegetation not met with elsewhere in the country (but very characteristic of N. and E. Ceylon). The lengthening of the moist season where the effect of both rainy periods is felt also influences the vegetation, as in the Nilgiris and the E. Ghats as far north as the Kalahandi hills in Central Orissa.

It would be anticipated that the value to vegetative growth of a given fall of rain would be appreciably influenced by the period over which it is spread, both in the rains period proper, and as a function of the number of days in the year. This is borne out by experience, so that other conditions being equal, the minimum fall necessary for the development of a given type increases with increasing length of the dry period. This effect appears to be less marked, the more xerophytic the type considered, and most pronounced for the types requiring the highest rainfall. There is also a less perceptible correlation with number of rainy days reflecting the distribution of precipitation within the rainy season.

TEMPERATURE AND RAINFALL TOGETHER.—If the same length of dry period is experienced, it appears that a rather greater rainfall is required with a lower temperature than a higher one to permit of the development of a given type, at least for the pronouncedly mesophytic types. Well developed wet evergreen forest occurs in the Western Ghats with 2,500 mm. rainfall and a 5 months dry season, but not with the same amount and distribution of rainfall in the cooler N. Bengal, though it occurs in equally cool Assam with only 3 months dry. The factors involved however are so complex and the data so incomplete that precise correlation is impossible at present.

EVAPORATION.—For plant life, available moisture is of critical importance. Of the total precipitation, a part is lost to the vegetation by interception on the aerial parts of the vegetative cover, a part by run-off depending on topography, soil, and duration and intensity of the rainfall, a part by downward percolation through the soil beyond the reach of the roots, and a part by evaporation.

It has been pointed out that the apparent loss by interception is not necessarily total. From a consideration of the energy relations, the evaporation of intercepted rainfall from wettened surfaces must reduce transpiration unless the incident radiation is enough to sustain both processes.

The determination of evaporation is not as simple as measurement of rainfall but indirect methods have been worked out which give acceptable approximations. Evaporation is regulated mainly by temperature and the relative humidity of the atmosphere but is also affected by rate of air movement. THORNTHWAITE (1938) has worked out a *Precipitation Effectiveness Index* (P.E.), *i.e.*, the ratio of Precipitation to Evaporation, in terms of rainfall and temperature.

BHARUCHA and SHANBHAG (1957) find that a good approximation for evaporation is obtainable from known values of barometric pressure, relative humidity and wind velocity, so that the Precipitation/Evaporation or P/E ratio can be determined. They also derive a correlation between P/E and the number of rainy days (D) given by the formula :

$$P/E = \cdot 065D + \cdot 0047D^2$$

It will be noted later that the main forest types of India fall very fairly within the ranges of P/E.

EVAPOTRANSPIRATION.— THORNTHWAITE (1948) later developed a new approach paying more attention to the role of the moisture stored in the soil and the energy relations involved in both evaporation and transpiration, now generally referred to as *evapotranspiration.* As actual values cannot easily be determined, the standard adopted was the *potential evapotranspiration* (PE) which is the value that would be attained from a vegetation covered surface if moisture remained in adequate supply. Perhaps surprisingly it is argued that it should make little difference whether the vegetation is grassland or forest. It may, however, be pointed out that there are conflicting views regarding potential evapotranspiration. Much experimental evidence has been brought forward that evapotranspiration does vary with climate, plant and soil type, although it appears that the effects of crop morphology on evapotranspiration rates are not large and that meteorological factors play a dominant role, where soil moisture is not limiting (PELTON, 1961). Potential evapotranspiration is estimated by THORNTHWAITE from mean temperature and day length (or Latitude), the latter being a measure of radiation or albedo. Knowing PE and Precipitation, it is simple to work out geographically and statistically the moisture available for recharging the soil month by month, the amount that will be withdrawn, so that each month will show a surplus (s) or deficiency (d) of water needed for evaporation. Annual values for s, d; and PE can be obtained as totals of the monthly figures and a *Moisture Index* calculated from an empirical formula (see THORNTHWAITE *et al*, 1955 and 1957).

It is apparent over most of tropical India, that the *length* (usually expressed in months) *of the dry season(s)* is very influential on the type of vegetation found. This factor has received special attention from GAUSSEN (1957) and his collaborateurs. The effect of temperature is allowed for by varying the limiting rainfall for a month to be counted as dry by the mean temperature, e.g., less than 75 mm. when mean monthly temperature is above 30° C, and less than 50 mm. for MMT of 20-30° C. He then plots monthly values of *T* and *P* (rainfall) together, using a rainfall scale in mm. twice that of temperature centigrade. In a wet climate such as Coonoor, the *P* curve is entirely above the *T* curve; in a very dry climate the converse will hold; in most Indian climates the curves intersect in two or more places, indicating periods of excess and deficit. The number of physiologically dry days each month is obtained by making appropriate deductions for the number of days with no recorded rainfall, for other days with traces of rain, misty days, and days of high humidity. Annual totals are derived and grouped in fifties from zero; the numerical sequence of the group is termed the *xerothermic index*, and this is used for mapping bioclimates. It is further found necessary to distinguish climatic regimes with two dry periods.

Coastal and montane climates.—Proximity to the sea or big lakes acts both as a moderator of temperature and as a humidifier of the atmosphere, and can have a considerable effect on the general climate and vegetation of the land so situated. This effect is allowed for at least partially in some of the classifications of climate described above, including GAUSSEN's. It is well-marked in Orissa. It should, however, be borne in mind that any such effect may be masked by other factors, e.g., along the West Coast the dominant factor is the orographical rainfall due to the elevated land mass of the W. Ghats which cause much heavier precipitation near the foot of the hills than on the coastal plain. The contrast of the very low rainfall over the flat delta of the Indus is very striking. A coastal situation again influences the wind factor of climate to be considered later.

Montane climates.—Mountain masses largely generate their own climate, India providing striking examples. The differences in the several factors of climate between a tropical montane tract and one at low elevations in temperate latitudes have already been mentioned. They find full play in the high hills of S. India, whereas the Himalayas are well outside the tropics so that both climatic conditions and some of the vegetation types are very close to those of more northerly latitudes. Mountainous country with its steep gradients greatly emphasizes the climatic effects of aspect such as differences in incident radiation including light, moisture relations, particularly in the soil, and exposure to wind—all in addition to the effects of altitude on temperature. In sum, montane climates are generally moister than those of the adjoining lowlands. The higher hills of Peninsular India are of special interest from the climate-vegetation viewpoint, though the vegetation has everywhere been greatly affected by human activities, all tending to render moisture conditions less favourable. The considerable difference in conditions (and vegetation) between an isolated hill with maximum exposure to mostly adverse influences, and an extensive land-mass of the same altitude is noteworthy.

The Himalayan mountain range is so vast a feature that it plays a great part in regulating climate over most of the country. Forming as it does an effective barrier to moisture bearing winds from the oceans to the south, it also conditions a dry montane climate in the inner ranges with marked effect on the vegetation. The Vale of Kashmir screened by the Pir Panjal range has a climate contrasting with that of the south side of the range, though with a very limited tree flora, the forests are less different than might be expected.

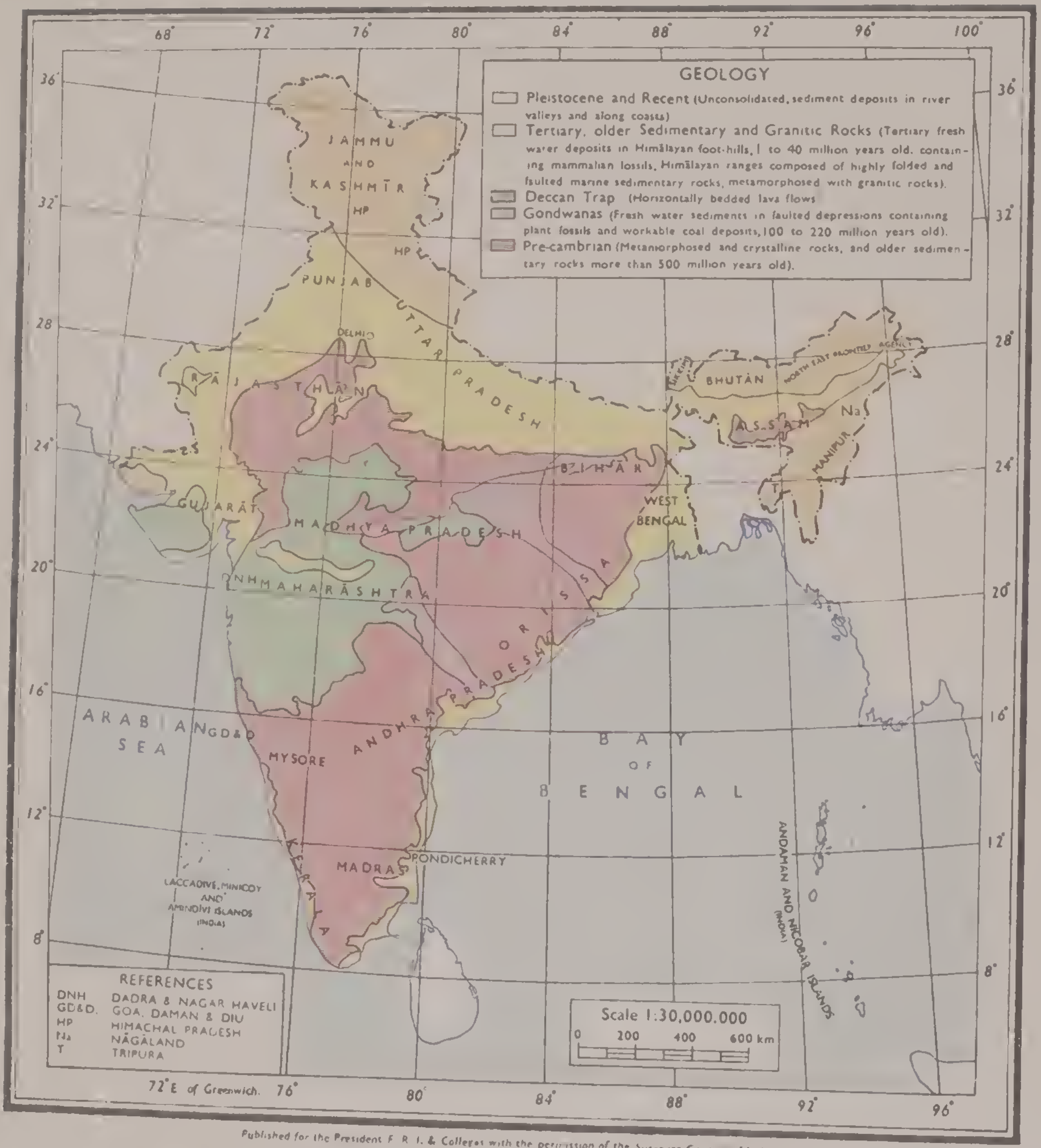
INCIDENT RADIATION.—Incident light intensity—and with it temperature—are influenced by aspect and gradient of the microrelief just as on the major topography. Full solar radiation reaches the top canopies but is diminished as it penetrates either directly or after reflection down to successively lower strata and ultimately to the soil, where part will be absorbed as heat, reacting on root activity. It has been demonstrated that the total absorption by a full cover of vegetation can vary but litter provided adequate soil moisture is available, but when this is not the case, the difference may be reflected by a wide difference in vegetation type, e.g., grassland instead of forest. The characteristic development of epiphytes in some forest types and their vertical distribution are determined jointly by light and humidity. It appears probable that the reduction of light intensity by cloud belts where they are prevalent, as locally on the hills of S. India and in the N.E., plays a significant part in the stunting and low rates of growth of the vegetation within them (RICHARDS, 1952, p. 152). In the tropical wet evergreen forests light intensity at ground level has been found to be less than 1% of that at the top of the canopy, with moving sunflecks during the middle hours of the day of varying intensity even upto 100% (RICHARDS, 1952, pp. 175-9). Satisfactory methods for measuring light intensity are not easy to devise. Among the various instruments that have been used the photo-electric cell alone meets most of the requirements; integrating devices are also desirable. Very little has so far been done in India.

Temperature records at different heights above the ground and in the soil, collected in and under canopies of different species for comparison with values in the open with no canopy, have been made by KRISHNASWAMY *et al.* (1957) and continued since then. They provide a measure of the magnitude of the differences. Of particular importance is the effect of a cover on liability of regeneration to be killed by frost or drought. A cover reduces radiation losses of heat at night, but at the same time reduces the heat received and stored during day time insolation, so that the net effect of the upper canopy will largely depend on other site factors. PURI (1954) found that soil temperature at all depths under sal forest was higher in the cold weather months than under the leafless teak or in the open.

WIND.—The effect of wind as such (in contrast to its effect on cloudiness, mist and rain) on forest type is limited and localized. On exposed sites, it has a stunting effect which may be quite marked as illustrated by the hill-top vegetation in the Andaman Islands and the ridge crest forests along the W. Ghats. Height is significantly reduced and crowns tend to be relatively low, branchy and dense; comparable effects are seen on the leaves which tend to be relatively small and tough. Along the coast, the mangrove forests do not show such effects, but the littoral vegetation which is exposed not only to strong winds off the open sea but to flying sand grains and salt spray, shows a marked reaction both in the poverty of flora and its morphology. *Casuarina*, *Cocos* and *Calophyllum* illustrate different types. Drying winds of the more arid regions clearly affect the vegetation to a considerable and even dominating degree : once again, this effect is exerted mainly through moisture relations.

TOPOGRAPHY.—In relatively flat country, the factor most affecting the vegetation is the minor differences of levels determining the movement of water both over and through the soil. Even a difference of a few feet or less may influence moisture conditions favourably or the reverse. This feature, though often complicated by other physical differences, is well-marked on alluvial plains with terraces at different levels. In the degradation of a plain, erosion often creates a pattern of plateaux, slope and bottoms

INDIA — GEOLOGY


GEOLOGY
Pleistocene and Recent (Unconsolidated, sediment deposits in river valleys and along coasts)
Tertiary, older Sedimentary and Granitic Rocks (Tertiary fresh water deposits in Himālayan foot-hills, 1 to 40 million years old, containing mammalian fossils, Himālayan ranges composed of highly folded and faulted marine sedimentary rocks, metamorphosed with granitic rocks).
Deccan Trap (Horizontally bedded lava flows
Gondwanas (Fresh water sediments in faulted depressions containing plant fossils and workable coal deposits, 100 to 220 million years old).
Pre-cambrian (Metamorphosed and crystalline rocks, and older sedimentary rocks more than 500 million years old).
REFERENCES
DNH DADRA & NAGAR HAVELI
GD&D. GOA, DAMAN & DIU
HP HIMACHAL PRADESH
Na NĀGĀLAND
T TRIPURA
Scale 1:30,000,000
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JAMMU AND KASHMĪR
HP
PUNJAB
DELHI
UTTAR PRADESH
RĀJASTHĀN
GUJARĀT
MADHYA PRADESH
MAHARĀSHTRA
DNH
BIHAR
WEST BENGAL
ORISSA
ANDHRA PRADESH
MYSORE
MADRAS
KERALA
PONDICHERRY
GD&D
BHUTĀN
NORTH EAST FRONTIER AGENCY
ASSAM
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ARABIAN SEA
BAY OF BENGAL
LACCADIVE, MINICOY AND AMINDIVI ISLANDS (INDIA)
ANDAMAN AND NICOBAR ISLANDS (INDIA)
72° E of Greenwich. 76° 80° 84° 88° 92° 96°
68° 72° 76° 80° 84° 88° 92° 96° 100°
36° 32° 28° 24° 20° 16° 12° 8°

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so affecting soil and hydrological conditions that the differences between the three site types are enough to support different vegetation types with a repetetive pattern or *catena*.

In hilly country, the factors of topography that exert most influence on vegetation are aspect and gradient. In the main, they are reflected in the variations caused in the altitudinal limits of species and vegetation types, the latter appearing to express the integration of many climatic variables.

The influence of aspect is much simpler within the tropics than in higher latitudes, being largely limited to its relation to wind direction, particularly moisture bearing wind. Thus a S.W. aspect facing the monsoon winds has a much higher and better distributed rainfall than the opposite N.E. aspect, which is in the rain shadow. The situation is accentuated where a whole range of mountains such as the Western Ghats or the Himalayas lie more or less across the wind, particularly when as in the former example, it makes the edge of a plateau; in this case the drop in rainfall on the lee side is typically very pronounced and no longer local, as typified by the whole Central Indian plateau.

The other major effects of variation in aspect are related to the consequent variation in insolation per unit surface. Southern aspects receive more solar radiation than northern in proportion to their latitude and gradient. Westerly and south-westerly aspects receive maximum amounts in the afternoon when the cooling effects of night conditions have been lost, in contrast to the easterly and south-easterly aspects where insolation is at a maximum in the morning. In higher latitudes, steepness of slope cancels out the effects of the lower altitude of the sun on a south aspect but accentuates it on a north aspect. All these differences affect the temperature in the first instance but even more influential on the vegetation is the effect on soil moisture. On steep slopes, the soil is shallow and quickly dries out so that almost universally the forest type carried is of a drier type, e.g. deciduous instead of wet evergreen in the W. Ghats, and in extreme cases, not even a tree type at all but scrub or grass.

The variation in the altitudinal range of a forest type on the various aspects is determined by a complex of factors including not only insolation, temperature and gradient with their effects on moisture, but by geology, stratigraphy, soil and adjacent topography, so that there is no rule by which a precise figure can be given for the upper limit of a type on a N. aspect, the limit on the S. aspect being known. However, the difference in the Himalayas is of the order of 350 m. on an approximately SW/NE axis.

MICROCLIMATE.—Whatever the general climate may be over a given area, the intensity of its several factors will vary considerably from place to place, and similarly at different levels above the ground within the vegetative cover. The differences in growing conditions result in variation in detail within a general type such as Moist deciduous forest, or even a mosaic of two or more different types, e.g., Subtropical broadleaved and Pine forests. Variations in floristic composition in all the strata commonly reflect variations in microclimate.

The most influential factors in microclimatic variation are light, temperature, humidity and wind. It should be remembered also that differences in the nature of rock and soil will affect the first two of these factors, primarily through the soil itself. A general survey of this field of microclimate is available in GEIGER's (1956, English translation 1957) "The Climate near the Ground".

(b) SOIL FORMATION

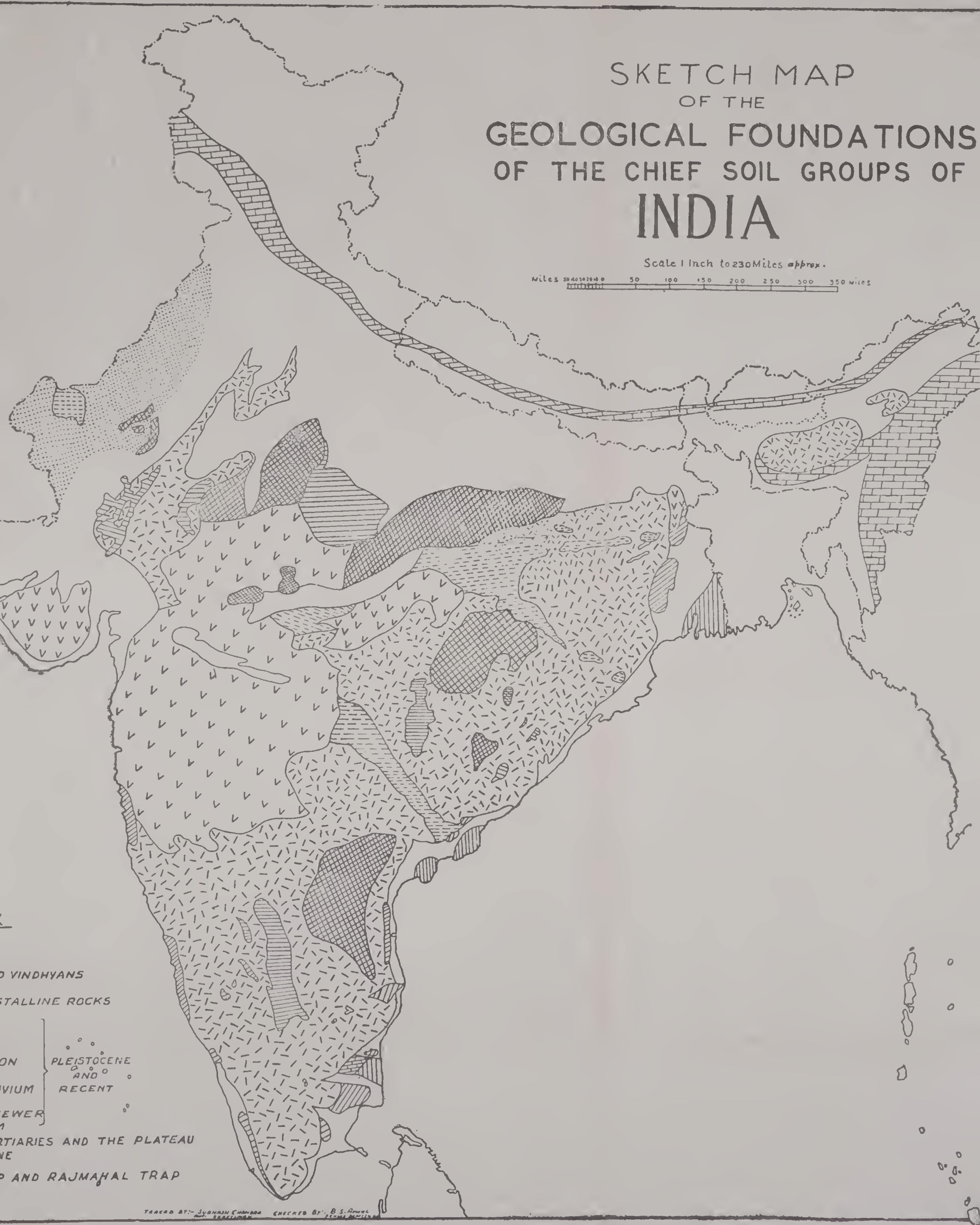
There are two main classes of soil to be considered, those formed *in situ* from the rocks underlying them, and those formed from transported material. The former predominate over Peninsular India and the Himalayas and the latter in the Indo-Gangetic plain and the valleys of the larger east coast rivers.

Confining attention to stable mantles not exposed to continued aggradation or erosion, in both sedentary and transported soils, the composition, texture and the physical condition often depend on the nature of the parent materials from which the soil is derived; in both cases the soil has been exposed for a longer or shorter time to the leaching effect of the precipitation, but in the transported soils—air or water borne—there has been a considerable sorting of materials. In any individual transported soil there will usually be a limited range of size of particle, from pure quartizite gravel to the finest clay, and also of many chemical constituents probably leading to concentrations unfavourable to plant growth, either too great (e.g., saline and alkali soils) or too low (major or minor mineral deficiency).

All soils remain exposed to continuous change after they have been formed or laid down, not only by physical erosion but by physico-chemical changes brought about by movement through them of water and dissolved substances. Leaching, accumulation and induration are the chief processes involved but detailed discussion is not necessary here.

As differences in soil influence the occurrence of forest types, and the vegetative cover influences soil processes thereby affecting the ultimate stability of the type, the evidence must be examined.

SOIL MATURITY.—It is widely accepted that climate affects the weathering processes of rock and the soil development itself in such a way that there is a tendency to convergence in the nature of soils derived from different rocks. The processes are slow but given geological time, the soil should become "mature", revealing this uniformity and stability in equilibrium with the climate—a *soil climax* comparable with the vegetation climax to be discussed later. Even if the generalization holds, the process is so slow in some cases, especially with secondary rocks and comparatively recent and unconsolidated deposits (e.g. moraines) that for practical purposes the soil in question may be of a character quite different from the theoretical climax. In other cases, one has to deal with immature detrital or aeolian soils which again may have a character of their own, as on scree slopes and shifting sand dunes. The *fossil soils* constitute another class of exceptions. They have been developed under quite different conditions of climate and variously exposed to present climatic and vegetational influences, in which 'maturity' or 'convergence' in the above sense is a very slow process indeed.



SKETCH MAP
OF THE
GEOLOGICAL FOUNDATIONS
OF THE CHIEF SOIL GROUPS OF
INDIA

It is of course possible that 'maturity' in soils is only a theoretical concept, in fact it has been suggested that "maturity implies senility" (BOURNE, 1934).

SOIL CLASSIFICATION.—As with climates, many attempts have been made todevise methods of classification combining genetic relationships with ease and convenience in field use, just as with vegetation. Reference must be made to standard texts (*e.g.* MOHR and VAN BAREN) for particulars. Again as with vegetation, there are many factors involved and boundaries are rarely sharp; for practical application it is sifficult to avoid using mixed criteria. It has also to be borne in mind that most of field studies and mapping inIndia have been done with an agricultural bias, i.e. studies of a relatively shallow upper layer and suitability for or productivity under cultivation, whereas the forester is more generally concerned with the morphology of the complete soil profile down to bedrock or the unaltered substratum.

A large scale soil survey has been made for India as a whole on methods drawn up by RAYCHAUDHURI (1946). The soil map published in 1954 shows the general distribution of the twenty main soil groups.

Indian soil types.—According to the latest classification of Indian soils (RAYCHAUDHURI, 1962) twentyseven broad soil classes have been differentiated. These are enumerated below. The corresponding groups shown in the 1954 soil map are given in brackets.

1. Alluvial soil (alluvial soils—undifferentiated).
2. Alluvial soil, highly calcareous (Gangetic Alluvium —calcareous).
3. Coastal alluvium (Coastal Alluvium—new).
4. Deltaic alluvium (Saline and deltaic soils).
5. Alluvial soil, affected by salinity and alkalinity (Grey and brown soils impregnated with salts).
6. Desert soil (Included in Desert Soils—grey and brown).
7. Deep black soil (Deep black or regur soil).
8. Medium black soil (Medium black soil) .
9. Shallow black soil (Shallow black soil).
10. Black soil affected by salinity and alkalinity (Included under 7, 8, 9).
11. Black soil undifferentiated (Included under 7, 8, 9).
12. Mixed red and black soil (Mixed red and black soil).
13. Red soil (Red loam soil).
14. Red gravelly soil (Red gravelly soil).
15. Red and yellow soil (Red and yellow soil).
16. Laterite soil Laterite soils, old alluvium).
17. Laterite and Lateritic soil (Laterite soils, high and low level).
18. Brown soil under deciduous forest (Included in Forest and Hill soils—undifferentiated).
19. Grey and brown soil (Included in Desert soils—grey and brown).

20. Hill soil
21. Podsolised soil
22. Forest soil, laterised
} (Included in Forest and Hill soils—undifferentiated).

23. Foothill/Tarai soil (Submontane regional soils; Foothill swampy soils).

24. Mountain meadow soil
25. Mountainous soils, undifferentiated
} (Included in Forest and Hill soils—undifferentiated).

26. Skeletal soils (skeletal soil).

27. Peat, muck, very humose and humose soils (Peat soils).

By far the greatest areas are occupied by the red soils (totally in the E. and S.), black (W. and C.), alluvial (N.) and hill (N.) types.

Alluvial soils (1, 2, 5) predominating in the Indo-Gangetic plains across the north of the country are often low in nitrogen and phosphorus, though less so in the forests than where they have been denuded. Potash is usually adequate as also lime which is liable to form a *kankar* pan, especially over bands of clay in the older and higher alluvium. These alluvial soils are usually deep, but may show marked stratification of sands, clay and loam and the vegetation they carry is greatly influenced by moisture and soil aeration.

Coastal sands (3) are met with at places all round the coast and carry characteristic vegetation. They are mainly quartzitic or calcareous sands with low silt and clay fraction. The depth is variable and the water table is characteristically high. The nutrient status is typically low, especially as regards nitrogen and phosphorus.

Saline and alkaline soils (4, 5) mainly developing in the drier parts of country in the N.W. and over the Deccan plateaux, are unfavourable to tree growth, few species being able to develop under the adverse conditions which are often further accentuated by inadequate drainage. A special class of such soils occurs in the extensive saline flats bordering the Rann of Kutch. As would be expected, the type of forest occurring is poor and open.

Arid and desert soils (6, 19) are typical of the west of the country in Rajasthan and Gujarat. They are often alkaline, usually with adequate mineral status, but with low organic matter and nutrient availability. Typically, they are also structureless. Climate as well as soil being unfavourable, only dry deciduous forest at best or open woodland or scrub, can exist.

Black soils (7 to 12) are mainly developed from basaltic rocks and so predominate over most of the Deccan plateau. They are usually heavy montmorollinitic clays which crack widely and deeply in the dry season. They are usually neutral to alkaline in reaction, poor in nitrogen and phosphorus but contain adequate potash and lime, in fact concretionary lime is usually present. The dark colour is due to the mineral constituents, humus content being typically low. Like the lateritic soils they have a marked influence on the vegetation. Teak occurs on these soils, but where they are deep and either dry or badly drained, or highly calcareous, inferior non-teak bearing dry deciduous forests and some times thorn forest (*Acacia arabica*) displace the mixed teak forests.

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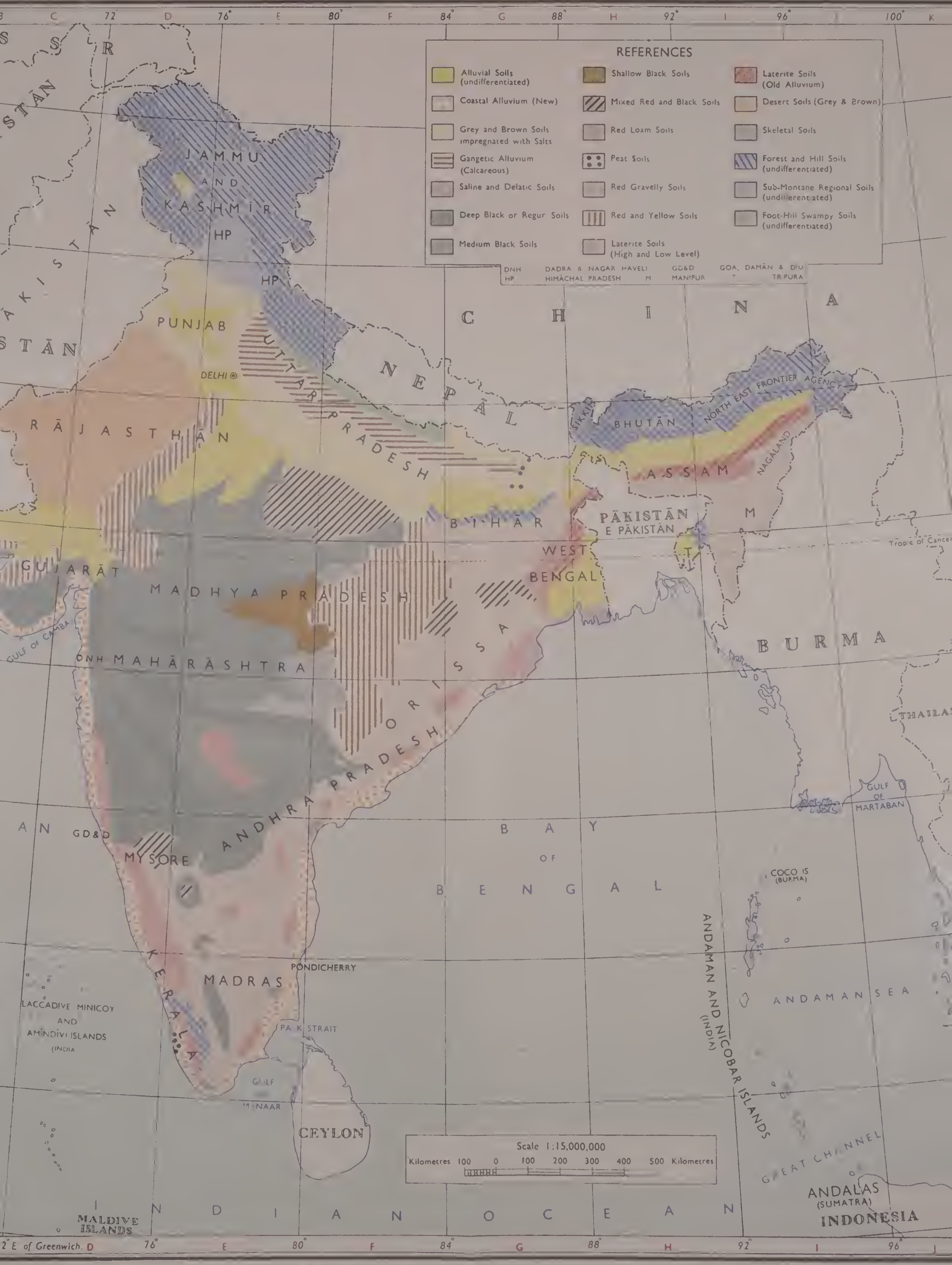
INDIA - SOILS FIRST EDI

INDIA - SOILS



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morphic.

Red soils (12 to 15) are mainly associated with acid granites, gneisses and schists and are ferralitic in nature; they are typically coarse, often with ferric concretions, with a neutral or acidic reaction, and poor in organic matter and mineral nutrients. The clay fraction is mainly kaolinitic. They tend to carry the moist evergreen and mixed deciduous forest with sal.

Lateritic soils (16, 17) are characteristic of the tropics with monsoon rainfall and tend to cap the hills in most parts of the peninsula; they develop mainly on the more basic rocks. They are usually acidic, poor in mineral nutrients and have a low silica/sesquioxide ratio. In the extreme case, the soil hardens on exposure to form the familiar vescicular laterite used for building, and forming extensive 'pavements' which are very infertile and slow to break down. These pronounced physical and chemical properties exercise a marked effect on the vegetation. Thus teak is not often to be found but sal is much more tolerant and *Xylia* is characteristic; *Anacardium* is also markedly tolerant. The influence of predominance of laterite and lateritic soil is not only on the distribution of individual species but affects the vegetation as a whole.

Foot hill soils (18, 23) have not been investigated in detail. Brown earths are usual, slightly acid or neutral, with high base status.

Montane soils (20 to 22, 24, 25) of the Himalayas are derived from a very wide range of parent materials, and differ fundamentally from most of those of the peninsula by being more or less immature. They show many of the characteristics of the well-known types of the N. temperate zone, though pronounced podsol profiles are rarely found. Brown forest soils predominate, mostly with adequate mineral nutrients and humus for plant growth which is accordingly regulated more by climate than soil. The soils are usually acidic in reaction.

Interest also attaches to the accumulation of raw humus in the fir forest at the higher elevations in the north west. This accumulation is considerable and unquestionably a hindrance to the regeneration of the dominant species, raising the question of the maintenance of the present forest type whether naturally or under management. The matter is further discussed on p. 22.

Skeletal soils (26) are of limited occurrence mainly on high land tops in the drier regions of the peninsula, and in the Himalayas. They support markedly xerophytic or degraded communities of vegetation but are not of great importance except locally.

Peaty soils (27) are rarely met with except locally in depressions in the wet alluvium of the Brahmaputra valley and in Kerala where they support a special type of woody vegetation or reeds.

EFFECT OF GEOLOGY AND SOIL ON TREE AND FOREST DISTRIBUTION.—A few instances of the association of individual tree species and soil types have been mentioned above. With limited exceptions, it still appears that the physical conditions of the soil, above all those affecting moisture supply, root aeration and availability of chemical nutrients, are much more influential on species and forest type distribution than the chemical composition as such. Many types such as tropical rain forest, chir pine forests and dry deciduous forest, extend across geological boundaries often involving considerable change of rock, with hardly any discernable alternation in appearance or composition. Examples can be quoted of abrupt change but they are exceptional. MOHAN and PURI (1956) have emphasized the differences in forest types in the Himalayas carried on dip and scarp slopes respectively. Interpretation is complicated by the usually different aspect and gradients prevailing in the two sites. Depth and moisture of the soil again are more important than nature of rock. Individual species are affected but not the forest type as a whole.

Lime requirement varies with species and perhaps with the types they dominate. Much has been written on this topic with reference to the distribution of teak in the mixed deciduous forests (cf. GRIFFITH and GUPTA, 1947), the evidence indicating that a fairly high available calcium status is associated with its frequent occurrence, as on most black soils. *Cupressus torulosa* and other trees have been quoted as being generally restricted to limestone formations, but whilst it is true that their major occurrences are on limestone they occur naturally on non-calcareous rocks and grow well when planted on other soils. The explanation must probably be sought more in exceptional lime tolerance favouring them against competitors, than in lime requirements.

The part played by laterite in influencing forest type distribution has also attracted much attention. As already mentioned teak generally avoids it but sal at least tolerates it. Of associated species, *Xylia* and *Cleistanthus* are prevalent on laterite but many others are absent. Physical conditions are liable to be highly unfavourable so that the forest is restricted in its development even where it remains basically the same as on adjoining red or black soils.

Useful reviews of soils of the teak forests (SETH and YADAV, 1959), the tropical evergreen forests (SETH and YADAV, 1960), and of the dry zone forests of India (YADAV, 1960), have been published recently. An extensive survey of dry zone profiles has been given by SETH (1960) and KHAN and YADAV (1962).

EFFECT OF FOREST ON THE SOIL.—In so far as the forest affects the soil on which it is growing, it must bring about changes from the conditions that prevailed when it originated. Such changes must make the soil more or less favourable than before both for the existing type or other types which might compete with it. If the soil improves in depth, physical condition and mineral content in the rooting zone, there will be a likelihood that a forest type with greater demands on the soil and of greater competitive power will displace the original type. That this can happen is well illustrated by changes occurring on the stabilization of moving sand or on a new riverain gravel bed. On one view, this process should continue until ultimately (provided the soil itself becomes mature) the climate, soil and vegetation are all in equilibrium, the latter two in a "climax" condition. Another view is that such an equilibrium is not attainable, but that cyclic changes will occur. Instances are accumulating suggesting that within a general type there may be minor units distributed irregularly each succeeding and being succeeded by a different unit. Since the distinction among these vegetation units is ultimately arbitrary and gradual transition is common, it would seem better to envisage a cyclic continuum rather than a mosaic of discrete units.

In view of the fact that by far the greater part of the forests of India have been subjected to clearing or selective felling, it is necessary to determine what effect this has on the soil and consequently on its future potentialities in respect of the forest types it will support. The most important effect of this kind is undoubtedly that consequent on clearing tropical evergreen forest. These factors occur in regions of high rainfall where weathering is very deep and leaching has been heavy. It is well established that the lower rooted layers of the soil are very deficient in mineral nutrients, and that the latter are concentrated in the surface layers being maintained by the organic detritus deposited by the forest cover. If such a soil is exposed by clear felling, the soil is degraded by the loss of existing organic content by rapid mineralisation, and by stopping of the continuous supply of organic matter containing the necessary mineral nutrients, and by exposure to sun and rain. If the area is then abandoned the soil is usually quickly covered up again and the original conditions gradually restored with no great or permanent loss, unless biotic factors, especially fire, are serious. If however it is put under agricultural or plantation crops, the stored fertility of the surface layers is very quickly exhausted and a permanent degradation results such that restoration of the original forest type becomes difficult or impossible. These effects are of course accentuated on hilly ground where physical erosion also takes place. On predominantly lateritic soils, the effects of clearing or seriously breaking the forest cover, accompanied by loss of topsoil, may be more far-reaching and a hard laterite pavement may be developed which is very unfavourable to tree growth and exceedingly slow to improve, if indeed the process is reversible at all. A striking example of this is the forest type found on denuded laterite on the coastal plain below the W. Ghats.

A method of study of the relationships between plant and soil as regards mineral nutrients that is being rapidly developed is that of *foliar analysis*—not that it need be restricted to leaves. The amounts of the nutrients that have actually been taken up by the plant are assumed to reflect both what the plant actually requires and what is available to the roots in the soil (regardless of gross content of the different elements partly in non-available forms). Selective absorption certainly takes place and where a given nutrient is in small supply, deficiencies may result affecting both species and type. The method is a promising one but the greatest care is required both in collecting the samples for analysis and in interpretation. Some studies have been made on ten species growing in plantations at Dehra Dun (PURI, 1954); considerable irregular variation was found at different seasons. The relations between sal soils and foliar contents have also been recently studied in some detail by SETH and BHATNAGAR (1960, 1961).

SOIL MOISTURE.—The moisture of the soil varies considerably from place to place within the general climate and forest type. These variations are largely correlated with those in light and temperature, soil moisture to some extent integrating the effects of the other factors. Microrelief becomes additionally influential in determining the movement of moisture through the soil, with the effect of variatio ir the soil itself superimposed.

These effects are naturally more marked where moisture at any time of the year is in limited supply, and the ground layer of the vegetation is liable to be more effected than the higher strata which are normally more widely and deeply rooted. In the wetter climates, the same causes may result in local excess of water continuously or periodically, with marked effect on the forest type supported; thus Cane brake or Freshwater swamp forest may alternate with Tropical wet evergreen forest. PURI's (1954) studies of soil moisture under sal, teak and *chir* plantations showed that there was little difference during the critical hot dry period between the sal and teak, whilst the values under *chir* were markedly lower at all depths down to 1·3 m.

CHAPTER III

DYNAMICS, COMPOSITION AND MORPHOLOGY OF FOREST TYPES

(a) DYNAMICS

In most forests there is evidence of current change going much beyond the mere ageing of the present community of plants. It is a not uncommon occurrence that the majority of the main canopy trees appear to be about the same age, a view that can be confirmed in trees showing annual rings. This observation inevitably leads to speculations as to how this can come about, what was there before the present trees arrived, and what will replace them when they die from old age of other natural reasons, if the forest is left undisturbed. In this example, one is often forced to adopt a theory of a catastrophic change, such as fire, flood, or exceptional drought—or of clearing by human agency, which will be considered in the following sections.

Plant succession.—Our understanding, of the natural processes involved was greatly advanced by the formulation by CLEMENTS (1916) of an hypothesis which appeared to provide a framework into which existing knowledge could be fitted and which permitted of a prediction as to how any given type would develop. This theory assumes that all plant communities will in time develop progressively towards a form which is in equilibrium with the prevailing climate and will then be stabilized as the *climatic climax*. The soil itself will at the same time react to climate and vegetation and similarly reach a stable climax. This succession of forms might be initiated on a dry site tending to make it moister, or on a wet site which it would tend to make drier, in both cases improving conditions for plant growth, rendering the site more mesophytic. If the vegetation has been disturbed in any way, a *secondary succession* will set in, similar to the primary successions but different from them in various ways. It was recognised that the successions proceeded at very varying rates and might in some cases be so slow as not to be demonstrable, whilst a non-climatic factor such as a highly infertile soil or fire might hold up the succession indefinitely at a *preclimax* stage.

Climax types.—CLEMENT's view of a single climatic climax for any given type of climate, the *monoclimax* theory, has been challenged by later writers who feel that it is not sound to consider climate as though it were the sole determinant and to assume for the preclimax a progression that will not take place at all or in any case not within the period over which the climate itself may change. The obvious alternative is a *polyclimax* theory which, while accepting the same general views of succession, considers that each pronounced variation in site conditions within a given type of climate will tend to have its own recognizable climax, typically an *edaphic climax*, developing on a particular soil type. The difference between the two theories in practice is mainly one of nomenclature but there is today a preference for the *polyclimax* view, with corresponding modifications in the theory of succession and climax.

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The concept of the climax itself requires further consideration. A basic assumption is that it must be able to maintain itself in its characteristic form, but it is usually very difficult to see how it can do this, particularly in the very mixed communities of the tropics. A simple theory would involve an all-aged crop in which any gaps in any stratum due to old age or accident would be filled by natural regeneration, top canopy species having to overcome the competition of the lower strata and grow through them. It is, however, very difficult to find clear examples of this process. In the mixed forest, it is very evident that many species differ in respect of the conditions needed to favour their regeneration, and it can often be noted that some of them regenerate best away from their own shade and the surface soil conditions their presence has brought about. Thus sal reputedly regenerates best where certain of the associated dominants, e.g. *Lagerstroemia parviflora*, from the top-canopy. Similarly for the species of mixed coniferous forest, the regeneration requirements of each species are seemingly better suited on ground dominated by another. These observations lead to the suggestion of a dynamic rather than a static equilibrium, with possibly cyclic alternations of varying complexity. The forest type maintains itself as a whole, as a single complex unit, but is continually changing on any given spot.

This view has been reinforced by studies of the vastly more complex tropical wet evergreen forest. A great number of species occur together very generally mixed singly or by small groups distributed at random, with the exception of some which are closely associated with a particular variable such as above average soil moisture. Regeneration varies enormously in amount and distribution. The lower strata through which recruits to the upper ones have to penetrate, show similar variations. The *mosaic theory*, attaining its most popular expression in AUBREVILLE's accounts (1949), is receiving wider support. The concept mentioned above for the less complex types is applied, the forest being viewed as built up of a great number of irregular small units, some of which with one or few dominants are recognizable; each of them will develop on more or less predictable but different lines. At any time, the different unit variations will always be present, but their position will continually be changing. HEWETSON (1956) has, however, objected to the use of the term 'mosaic' as implying a fixed size and outline which can rarely be demonstrated in practice. He summarised his attack on the climax theory to the effect that the tropical forest should be considered as a continuum in which the parts are in unstable equilibrium. With this may be noted GOODALL's (1954) views on the classification of vegetation that it is unavoidably arbitrary and as such unacceptable, so that even if it is more troublesome, one should study and work with continua.

The concept of continua has attained its logical culmination in the theory of vegetation gradients and climax patterns. This hypothesis adopts an intermediate position in rejecting the absolute convergence towards and homogeneity of a climax type as a whole (monoclimax) or of various units within it (polyclimax). The climax is interpreted as a partially stabilized 'steady-state' adapted to the whole pattern of environmental factors in which it exists, exhibiting similar or convergent patterns in adaptation to similar environments, but showing a continuous change along a continuous environmental gradient. Since whatever affect plant populations may affect the climax composition, there is no absolute (climatic) climax for any area, and the prevailing climax is a function of the sum total of all the factors of the mature eco-system, i.e. climate, soil, other site factors, biotic influences, availability of species and their characteristics, dispersal and chance. From this it follows that all climaxes should be at the same time physiographic, edaphic, biotic as well as climatic, and furthermore that distinctions between the climatic climax, sub- and pre-climaxes, edaphic climaxes etc., have no logical basis. The climax is accordingly to be viewed as an *average* or *most probable* population (WHITTAKER, 1953).

For the present purpose of providing descriptions of the chief recognizable forest types of India, we have found it most convenient to continue the earlier practice of referring to the type that predominates on sites and soils of medium depth and fertility as the climatic climax, describing as edaphic climaxes those types which appear to be the expression of markedly different site conditions.

This nomenclature permits differentiation of types the development of which is predominantly governed by climate or soil factors, these factors being the most easily apparent in the field. In adopting this system, we do not however imply the acceptance of either the monoclimax or the polyclimax view since detailed ecological studies on successional patterns are not yet available for India. The concept of climax patterns is implicit in the definition of a forest type as an average population with distinct broad physiognomic and structural characteristics. Thus we do not take a definite stand on the validity of the monoclimax, polyclimax or climax pattern schools of thought, nor is such a decision needed for our purpose of evolving a usable classification for forestry purposes. We, however, incline to the view that the theory of climax patterns perhaps provides the most acceptable frame work for detailed studies of vegetation of Indian forests.

Grasslands.—A note is required on the Grasslands of India, a field in which much new information has been collected in recent years, filling in large gaps reflected in the paucity of the data on the grasses included in the 1936 Preliminary Classification. There has been a good deal of discussion of their ecological status under the various climax theories. There is general agreement that many of these grasslands owe their existence or at least maintenance to biotic factors, chiefly fire, and there are many examples of progression on protection to woody formations of various types. There remain, however, three types on which opinion may differ.

Firstly, there are extensive areas in the big alluvial valleys subject to inundations of varying depth and duration. The grass is medium to tall (4 or even 5 metres) and dense and it is almost invariably burnt annually to render it more easily penetrable and to get a new and early flush of growth. Much of this grassland appears very stable and likely to remain so as long as present conditions continue, even without burning. For this reason, some authors assign climax status to it. On the other hand, every inundation deposits another layer of silt gradually building up the surface level, and it seems inevitable that in time this process will have gone so far that the upper layers of soil will become drier and better drained to an extent that will lead to colonization by trees. The beginning of this can often be seen on the slightly raised levels along the river banks. For these reasons, we feel that the non-climax or seral status is clear and we have described it as such.

The second disputed case is the montane tropical and subtropical grasslands of South India. There is evidence that part at least of them have been present for centuries but this seems to be taken as equally evidence of climax status. There is even more definite evidence that the boundaries have been greatly extended by clearing and burning in more recent times, at the expense of the fire-tender temperate evergreen forest that adjoins. The protagonists of the grassland climax view have not been able to particularize the site factors that should differentiate the grassland site from the forest site beyond the fact that a limited area in valley bottoms is now subject to frost (RANGANATHAN, 1938). BOR (1942) also takes the view that the somewhat comparable grasslands of the Shillong Plateau are secondary to temperate or subtropical evergreen.

Finally, considerable areas dominated by short grasses occur as degradation stages of open woodland or savannah formations in saline-alkaline lands. There is no doubt that the type is primarily edaphic but maintained as grassland under severe grazing pressure.

(b) FLORISTIC COMPOSITION

Floral regions.—The floristic composition, and therefore to some extent the structure and appearance of a forest type, depend on the local flora, i.e. the number and character (including special adaptation) of the species that occur in the neighbourhood and so are available to compete for survival on any given site. As a possible illustration of the result of limitations in the available flora may be mentioned the montane wet evergreen forest of the Nilgiri hills where the height and annual growth seem to be far below what the site could carry and in remarkable contrast to local plantations of exotic species.

The flora of India varies considerably in different parts of the country both in specific identity and in number of species. Some species occur throughout whilst others are restricted to quite small areas. Comparative studies have led to the differentiation of a number of floristic regions, the following nine being usually now recognised :

(1) Western Himalayan
(2) Eastern Himalayan
(3) Indus Plain
(4) Gangetic Plain
(5) Central India
(6) West Coast (Malabar)
(7) Deccan Plateau
(8) North-East India (Assam) and
(9) Andamans and Laccadive Islands.

The Western Himalayan flora differs from the Eastern Himalayan one in the greater representation of conifers. While the European element is conspicuous in the former, the Malayan, Chinese and Burmese are prominent in the latter. The Indus plain flora has received important North African components. All the regions have the majority of their species in common but also an appreciable number that are peculiar to them or are in common with only some of the other regions.

Endemism.—It has been computed that at least 47% of the dicotyledons of India are endemic, the largest proportion occurring in the Himalayan region which has been isolated by orogenesis and glaciation. Among endemic tree genera, the following may be mentioned : *Poeciloneuron, Mansonia, Chloroxylon, Ougeinia, Butea.*

Migration.—These peculiarities of distribution inevitably raise the questions as to where the different species originated and whether they have arrived by migration from other parts. Examination of the world distribution of the individual species indicates that apart from species which have probably originated in India there are contributions from the Malayan, Chinese, Australian and N. African regions. It is also evident that within India itself there must have been migrations to account for the presence, for example, of a form very closely related to the Himalayan *Rhododendron arboreum* in the hills of South India.

The subject of plant migration is only marginal to the study of forest types but the outline is useful. It appears to be established that the migrations mostly took place in waves during Pleistocene times, displacing in part an existing more uniform flora. Considerable earth movements were involved together with associated climatic changes, among them those brought about by the successive glaciations. A commonly accepted view is the Satpura hypothesis which would link the present hill ranges of the Peninsula with the Himalaya; down-faulting may have caused the gap through which the Ganges and Brahmaputra now reach the Indian Ocean. It is necessary to assume land bridges to account for common features between Malaya, S. India, Ceylon and the Andamans, but the routes followed by migrating floras were probably circuitous. Reference may be made to PURI (1960) and the bibliography cited by him, notably CHATTERJEE (1939) whilst GOOD (1947) has published a useful monograph on the general subject of Plant Geography.

Prehistory.—The geological history of the flora of the Jhelum valley in Kashmir has attracted much attention owing to the existence of rich deposits of fossil impressions in some of the Karewa clays laid down in the Tertiary lake of which a part still exists. Identification of the leaves and other parts of a large number of species has been possible and the evidence greatly extended by studies of fossil pollen. The most interesting features are the proof that the oaks, now virtually absent from the Valley, once predominated, and that other coniferous genera such as *Larix* were present though no longer found in any part of the W. Himalaya. It is easy to misinterpret the evidence, but MITTRE (1961) has recently published a most useful review.

Palynological evidence also suggests that the subtropical and montane temperate flora extended more widely in proto-historic times than at present. Thus pollen grains recovered from Maski (A.P.) in lime deposits dating to *circa* 2nd Century B. C. have been identified as resembling those of pine, *Brassica, Campanula, Stellaria, Lychnis* and

Juglandaceae. Some pine tracheids have also been identified (MITTRE, 1957). The present vegetation of this site in gneissic country in Andhra Pradesh is predominantly dry deciduous scrub.

The above is, however, an exception. Available evidence indicates that the climate and vegetation of India have been essentially stable during the last five millenia, except for changes brought about by biotic factors attendant upon the settling of virgin land, the degradation being most pronounced in Southern Punjab and Rajasthan. Slight shifts in the monsoon regime and drainage pattern have probably accentuated retrogression. Evidence from diverse sources, including identification of plant remains from numerous archaecological sites, has been critically reviewed by SETH (1962).

Invasive exotics.—*Eupatorium* and *Lantana* may be specially mentioned. Whilst these invaders seem likely only to delay natural succession, the spread of the now naturalised *Prosopis juliflora* may lead to a different type of succession and even a different climax. Large areas in typical habitats are being rapidly colonised by this species (Plate 64) which is maintaining its ascendancy by regenerating profusely. The salt flats bordering the Rann of Kutch are a case in point where *Prosopis juliflora* is now the most prominent element of vegetation; other *usar* tracts and dry areas as in Rajasthan are being colonised by this species with varying speed. There is no doubt that *Prosopis juliflora* has come to stay and must now be taken into account as a permanent feature of Indian vegetation. We have accordingly treated it as such, although its initially exotic origin has been suitably indicated.

Another, but far less important, example is the semi-gregarious distribution of *Anona squamosa* in certain dry habitats in Andhra Pradesh.

(c) Morphological Characters

As difference in morphology has been found to be the most suitable basis for classification of forest types, the chief characters involved may next be briefly reviewed with a general reference to RAUNKIAER's (1934) classic work dealing with many of them.

Leaf characters.—For present purposes, the main features are variations in size and texture, together with duration which determines whether the foliage is evergreen or deciduous. Much has been written on the significance of the *deciduous* habit in reference to classification of forest types, and all authorities have found themselves obliged to attach considerable importance to it. It is obviously related to climatic conditions whether associated with seasonal low temperature or dryness, and yet where types are mixed (e.g. in the Andaman Is.) they may be leafless at different times, just as in a mixed wood the individual species show a regular sequence of leaf-fall and coming into new leaf, although all experience the same climate and microclimate. The leafless period of a deciduous species varies considerably over its geographical range, being larger where the dry season is longer, and it also varies from year to year in the same way. In many species, e.g. *Syzygium cumini*, the old foliage normally persists for twelve months or a little more, so that they must be termed evergreen, but they are effectively deciduous under adverse conditions. Teak is virtually evergreen where rainfall is abundant and well distributed, whereas in the dry parts of its range it may be leafless for nearly half the year. In assessing the value of the character for type classification, it has to be borne in mind that it is determined by the genetic constitution of a species and may persist under conditions quite different from those in which it was evolved and fixed, thus the genus *Salmalia* is deciduous whether in a dry or wet type of forest, and conversely for the evergreen *Syzygium cumini* and *Schleichera oleosa*. Shedding of foliage often exposes flowers or fruits more effectively and so facilitates pollination or dispersal, both essential processes only indirectly connected with climate. This must not be confused with the normal leaf fall, the point being emphasized by the fact that some trees shed the leaves on their flowering branches long before those on the non-floriferous branches, e.g. *Butea monosperma* and mango.

In tropical forest it is usual that more of the top canopy trees (species) are deciduous than in the lower strata. Even in the wet evergreen type, many of the emergent trees are at least briefly deciduous, whilst in the moist deciduous types in which practically the whole of the top canopy is deciduous, many of the lower canopy trees are evergreen, (e.g. *Mallotus philippensis*) and the shrub layer equally or more so. Even in the dry deciduous types some of the undershrubs are evergreen (e.g. *Adhatoda*). A useful review of this topic has been given by RICHARDS (1952).

A foliage feature that often makes a strong visual impression is the colouring of the leaves either when expanding or just before being shed. The bright red colour of new foliage in many species of the wet evergreen forest is definitely a feature of the type (e.g. *Hopea*) though some species more typical of the moist deciduous forest (e.g. *Schleichera*) also exhibit it. Although the foliage of some species of the tropical forests colours up before falling, there is nothing comparable with the pre-abscission general bright yellow of the montane temperate deciduous forest in which new foliage is equally uniformly light green without any red. In the tropical wet evergreen, some species (e.g. *Elaeocarpus* spp.) always have some conspicuously bright red leaves about to fall, which aids identification but is not a general feature of the type, the leaves usually being shed when they are still green.

Leaf size has also been much studied in relation to environmental conditions and forest type. For this purpose, in the case of the compound leaf, the ultimate pinnae should be taken as the unit. In a general way, the largest entire leaves are found in the lower strata of moist types, e.g. *Musa* in wet evergreen forest. Although there are species in the deciduous forest types with large simple leaves such as teak, *Dillenia* spp., etc., they are the exception rather than the rule and are of much tougher texture than those of the wet forests. Most observers of the wet evergreen or rain forests have commented on the predominance of simple leaves of moderate size—mesophylls—RICHARDS (1952) again having brought together existing information on this topic. There are other leaf features such as structure of cuticle, thickness, nature of the leaf tip etc., for which the medel condition differs from type to type and so can be used in differentiating types.

Stem and root characters.—The *development of buttresses* at the base of the bole is often a striking feature and its prevalence appears to be related to site conditions and forest type. It is definitely absent from the driest types but so are the tall trees on which they might be expected; it is also absent from the montane forests, both broadleaved and coniferous. As with some of the characters already discussed, it is evident that a tendency to buttress formation is characteristic of certain genera, e.g. *Salmalia*, which are not confined to one type but exhibit it in a variety of sites with different conditions. It has been found that the development of buttresses is associated with absence of a pronounced tap root, the position of the buttresses being usually vertically above the major lateral roots; large lateral roots and feeble tap roots are usually found on soils of shallow rooting depth whether the shallowness is due to rock, pan, high watertable, or sterile and badly aerated sub-soil. Once again, reference may be made to RICHARDS (1952) for a detailed consideration of the subject.

The *root systems* of the trees of the tidal forests form one of their most striking features. The stilt roots of *Rhizophora* are unparalleled in other types of forest, though not a few trees of dry land forests, e.g. *Dillenia* spp. and *Ficus* spp., develop aerial roots in a somewhat similar manner. The feature seems so well suited to the general site conditions of the mangrove forests that it is difficult not to view it as adaptive. Here again, however, a genus such as *Carallia* may develop stilt roots even when growing on dry land. The knee roots and pointed pneumatophores of many of the other typical trees of the mangrove forest are obviously functionally adapted to the prevalent site conditions, and may be paralleled in freshwater swamps; good examples are rare in India though *Myristica* spp. have knee-roots and *Lophopetalum* spp., develop low horizontally spreading buttresses. Such features may be developed by a wide variety of taxonomic groups normally without them, when representatives occur in swamp forests; *Shorea* spp. and even conifers (*Taxodium*) illustrate this point.

Bark characters.—Not much attention has been given to the variation of bark with forest type, but some correlations exist. The rarity—often absence—of rough, corrugated or scaly bark in the wetter types is very marked. At the other extreme, smooth bark is unusual in the drier types where thick rough bark strongly predominates. Thin barked trees are almost completely eliminated in savannah and other dry (or seasonably dry) types subject to fire, though other factors are involved so that there is no direct correlation between bark thickness and fire resistance. Thus teak is relatively thin barked and survives (though not without injury especially to the timber). Rough bark provides a good footing for epiphytes and facilitates growth of climbers.

Thorniness.—This character is closely associated with the dry open types of forest being exemplified best by the genus *Acacia*. Such forests are exposed to maximum damage by browsing animals, feral as well as domestic, and the prevalence of thorniness must be taken as related to the conditions in which the biome has evolved. As conditions become moister the proportion of thorny species drops to almost nil in the tropical wet evergreen where it may be represented by a few species of genera more typical of the drier types. The moister forests do, however, include a few genera or species characterized by spiny tubercles as in *Zanthoxylum* and *Salmalia*, and compound spines, often with a flexible base, as in *Flacourtia*, on the main trunk where their presence would certainly greatly hinder climbing animals.

Root suckers.—Whereas coppicing ability is of very little significance in the absence of biotic factors other than fire, ability to develop root suckers may be a useful contributory factor in extending the area ultimately occupied by a single individual. The conspicuous examples of this feature tend to occur in the deciduous forest exposed to biotic damage of many kinds usually involving damage to the root systems, e.g. *Diospyros melanoxylon, Dalbergia sissoo* and *Butea monosperma.* This damage strongly stimulates the production of root suckers, which may be absent without it, but suckering also occurs without injury as in many *Bignoniaceae* and poplars.

Flowering and Seeding.—Season of flowering is usually closely related to climatic regime and so varies with forest type. In wet tropical forests and the mangrove forest some species are in flower at any season, especially in the lower strata. Just as the effect of season on leaf-fall is most pronounced in the emergents, so it is on flowering. Very little information on this subject has been recorded in India, but in the few tracts where the climate is virtually non-seasonal, it is possible that, as in Malaya, some species have two flowerings annually.

In the deciduous forests, there is a conspicuous contrast between species which flower when leafless such as *Lannea* and *Salmalia,* and those flowering with the new leaves like sal and *sissu,* or later when in full leaf like teak. The relation between flowering and climatic season is well illustrated by the variation met with in teak which flowers within a month or so from the onset of the rainy season, i.e. in July/August with the S.W. monsoon and in December/January where only the N.E. monsoon brings the rain.

In the temperate forests, flowering is usually dependent on the rise in temperature after the cold season, and so is successively later with increasing altitude. In the ground flora and shrub layer, especially at high altitudes, there is a tendency to come into flower very early, as in *Viburnum* spp., the linked site factors being the shortness of the warm season for ripening the fruit, and the rapid densification of the foliage as the season advances.

Gregarious flowering and seeding is of significance where it occurs since conditions are considerably and abruptly changed, especially for regeneration, when this phenomenon takes place. There are no Indian records of its occurrence from the wet evergreen forests, but it is frequent in the lower strata of moist deciduous forests, less so in the semi-evergreen and dry evergreen types. The outstanding example is provided by the bamboos, flowering on long cycles gregariously over areas of varying but sometimes of very wide extent. As the clumps die after the seed is shed, the light intensity and root competition factors of the site may be completely altered. The subject has attracted particular attention with reference to teak regeneration, but the maintenance of the tree cover and its specific composition must be greatly influenced by ability to respond to the marked change of conditions.

The position is similar in respect of the many gregarious shrub species of *Strobilanthes* with cycles of 3 to 12 years, some of which extend into the temperate montane types and when fully developed form a dense and complete ground cover.

Cauliflory is another feature which differs in its frequency in different forest types. In pronounced form with the flowers on the main stem and thicker branches, the phenomenon is almost restricted to the wet tropical forest. *Artocarpus heterophyllus* is one of the few large Indian trees with this character, whilst *Ficus glomerata* and other species of the genus extend into drier climates.

Pollination methods do not appear to be markedly associated with forest type, except that wind pollination is very rare in the wetter types. Pollination by birds is very uncommon in the temperate montane types where anemophily prevails, notably in the conifers and *Cupuliferae*, *Butea*, *Alnus* and *Juglans*. Conspicuous red flowers are predominantly bird pollinated and mostly tend to occur in the deciduous types, e.g. *Salmalia*, *Butea*, *Erythrina* and *Firmiana*, and to open when the trees are more or less leafless.

Seed dispersal.—The efficiency of seed dispersal is obviously of great significance in maintaining a forest type both as a whole and for the individual species. In the colonising of a bare site whether new, such as a mudbank, sand dune or landslip, or secondary as abandoned cultivation or gaps caused by wind throw, lightning or fellings, the species that arrive first gain a great advantage over later comers. The first colonisers tend to have small seeds, either winged like *Betula* and *Anogeissus*, or plumed like *Salmalia*, *Salicaceae* and many *Apocynaceous* trees and climbers, or extremely small and light as *Adina* and *Macaranga* or light pods easily transported by wind and water such as *Dalbergia* and many *Acacias* whilst in other species, the seeds are disseminated by birds as for *Broussonetia*, *Trema*, *Morus* and *Vitex*. Few of these trees form a significant part of the forest which finally comes to occupy the originally bare site though single individuals may persist. In a closed canopy, especially if it is evergreen, wind dispersal is not so effective as other methods and is rare. In the tropical wet evergreen forest, seed or fruit dispersal by birds and animals is usual, though large heavy seed dropping to the ground may also be spread by surface water flow. Very many different animals play a part in seed dispersal, the size, shape, appearance, colour and taste of the fruits all varying in accordance to attract elephant, bison, deer, monkeys, birds, fruit-bats or rodents. In swamp forests, dispersal by water is very common, as illustrated by the wide variety of genera forming the tidal forests and the fringing and freshwater swamp forests (*Trewia*).

(d) STRUCTURAL CHARACTERS

Stratification.—It is frequently to be observed in a forest that the trees, shrubs and herbs appear to be differentiated into several layers or strata. In all the more luxuriant types, there appear to be more or less well defined strata for the tallest trees, which tend to stand singly or in groups, well above a more or less continuous main canopy; below this may be successively smaller trees, shrubs and ground layers. Studies by the transect profile methods provide a quantitative measure and do in fact confirm the subjective impression. In a general way, the more favourable the site to tree growth, the more such strata are developed, so structural stratification is accepted as one of the diagnostic characters of a forest type. The several strata are composed each of a separate group of species and ordinarily the fact that younger individuals of the higher strata must grow through all the lower strata does not obscure the general picture. It is difficult to assign any reason for this differentiation into strata, and much work remains to be done on it.

Climbers.—These plants are present in most types and their size, situation and relative abundance contribute to the total character of the several types. Climbers are probably at their maximum in the semi-evergreen and moister deciduous types being (except locally) rather less numerous in the wet evergreen, decidedly less in the drier forests, and relatively rare in the thorn and mangrove forests. The climbing canes favour wet ground where they may largely replace the tree canopy and add a characteristic appearance to the vegetation as a whole. When the canopy of the evergreen or semi-evergreen forests is broken from whatever cause, it is not unusual for a dense climber tangle to develop, and it may take a long time for the tree species to penetrate it and recover their original dominance. Locally the same phenomenon may be observed in the deciduous forests, the genera *Combretum* and *Acacia* (thorny spp.) tending to predominate.

Epiphytes.—Epiphytes are dependent on the limited part of the local precipitation that penetrates the upper canopy, supplemented by the flow of water down the branches and trunk. Their water economy is raised by a variety of xeromorphic features but even so, their survival depends on it and must be related to the atmospheric humidity prevailing at different levels above the ground in the type of forest concerned. Equally they are dependent on receiving an adequate light intensity and (except for cryptogams) on being suitably situated to ensure pollination and seed dispersal. It is accordingly to be expected that there will be a characteristic type of development of epiphytes for each forest type.

The wet evergreen forests offer the most favourable conditions as regards moisture, but light intensity is low except well above the ground, where the maximum occurrence is found. Semi-evergreen types might be expected to be favourable in respect of both requirements. The moist deciduous forests experience a long dry season, so that any epiphytes must be able to survive through it; only a few well-equipped with zerophytic adaptations can do so. The dry deciduous forests are still more unsuited and epiphytes other than bryophytes are virtually absent. The wet montane subtropical and temperate types support a very rich cryptogamic epiphytic flora and not a few phanerogams both herbaceous and woody, notably *Araceae*, *Orchidaceae* and *Ericaceae*, but the drier temperate forests are very poor in epiphytes. Mention must be made of the semi-parasitic epiphytes of the family *Loranthaceae* which by obtaining their water and nutrient requirements from their hosts, are largely independent of climatic factors. They are most abundant in the moist deciduous types but extend into the temperate evergreens both broad-leaved (e.g., *Viscum* on oaks) and conifers (e.g., *Arceuthobium* on *Pinus wallichiana*). The leafless holoparasite *Cuscuta* (*Convolvulaceae*) is sometimes conspicuous on woody plants of the Dry deciduous and Thorn forest types.

(c) BIOTIC INFLUENCES

History.—In virgin forest it is not possible in the absence of annual rings to verify suppositions concerning to past development as under the intense competition for light and space trees of very different girth may be of the same age. On the other hand, there is often, at least locally, all the appearance of an even-sized and even-aged main or top canopy which may reflect little more than a slowing down of growth with increasing age till overmaturity and mortality sets in, tending to reduce the range of diameter. One of the results of modern studies has been to reveal how few of the supposedly virgin forests have in fact been free from human interference in their past history, owing to the widespread practice of *shifting cultivation and nomadic grazing* and the extensive tracts over which the peoples dependent on this practice have ranged. Evidence of past clearing may persist in a variety of forms. Thus it is common practice when clearing an area to leave standing a few of the bigger trees because they are too much trouble to fell, or because of some superstition (as with *Ficus* spp.), or for fruit or shade. Such trees often persist and can be recognised for what they are long after the clearing has reverted to forest. Very often one finds in the apparently virgin forest, trees of cultivation such as mango and tamarind. More or less sharp boundaries, often following an unnatural course—a straight line or a contour—between visibly different types, are also indications of interference; as also obviously are remains of former terraces in hilly country. Good examples of this are common in the evergreen forests where clearings have been made for coffee or other crops, and subsequently abandoned. In some cases, no evidence is discernible above ground, but small pieces of charcoal, bricks or even pottery fragments found on examining the soil, tell their tale. Whether in the hills or the plains, there is very little forest in India that can be accepted as having always been free from biotic influences. The greatest safeguards have been steepness and poverty of soil, and unhealthiness for human occupation, but none of them has been universally effective.

Outside the wetter mostly evergreen forests, in addition to permanent or temporary cultivation, *fire and grazing* have played an extremely influential part in determining the forest type now occupying the land. These practices almost invariably have the effect of rendering the site less favourable to tree growth through a reduction of moisture levels in air and soil, and often through erosion of the top soil. Accordingly, over large parts of the country, we find forest of a type otherwise associated with a drier climate or a poorer soil, and where fire is a factor, the flora is reduced to those species which can survive it.

Fire.—In addition to the general aspects of the effect of burning on the present distribution of forest types there are further points to be noted. Every state in India has extensive tracts of apparently stable communities conditioned by periodic fires. In several ways burning tends to obscure differences in climate and site, converting a variety of types to the same "fire preclimax" characterized by a very irregular broken canopy of height much inferior to the potentialities of the site, with short, crooked, branchy and scarred trunks and thin crowns, standing over grass of height and density (unburnt) depending mainly on the soil moisture available. Where the grass is dense and therefore the fire fierce, the shrub layer tends to be severely restricted and limited to annual shoots destined to be killed back by the next fire. Where the grass is low and sparse, the shrub layer, usually thorny and otherwise xerophytic, is more in evidence and partly escapes destruction through paucity of inflammable material.

Even in the case of trees that are fairly fire-hardy when above a certain size, fire will effectively prevent all regeneration except for a limited number of specially adapted species. The latter are characterized by being liable to build up a large rootstock despite annual destruction of their above-ground growth, sal being an outstanding example. *Pinus roxburghii* provides an interesting example of this faculty of seedling survival despite burning, in a genus normally devoid of it. An extensively branching underground root system able to send up adventitious shoots achieves the same end as with *Zizyphus* spp. In fact the ability to produce rootsuckers is a common feature among the species of the fire preclimaxes (*Salmalia*, *Stereospermum*, *Butea*, *Diospyros*, etc.).

Fire resistant bark is essential to survival. An outer corky layer that will char without igniting is usually present, but some species such as *Salmalia* are effectively protected by a thick smooth and sappy bark. As the fire usually sweeps past almost in a matter of moments, low heat conductivity is one of the chief factors and lack of it may account for extensive mortality in rough-barked deodar even without any external charring. Gregarious habit may also be a help to survival as may be exemplified by sal; patches of saplings may so thin out the grass by shading that they may become established after a year or two of chance escape from burning.

Shifting cultivation.—What happens to a patch of cultivation when it is abandoned depends on a number of contingencies. Reference has already been made to the practice of leaving some of the big trees of the original crop, and these will provide a source of seed, will attract birds which may drop seed of other species, and will cast some shade helping to maintain light and moisture conditions favourable to the regeneration of many tree species. If the area has been previously cultivated, it is unlikely that many of these trees will survive, and as noted before, they are liable to be *Ficus* rather than other species. The size of the clearing is important. The larger, the more the conditions are altered and the further off seed trees will be. Duration of cultivation is also important, as regrowth from surviving stocks of the original vegetation, tree or shrub, will be gradually eliminated by a repeated cutting back and so will not quickly restore the ground cover including at least some of the original species. Usually the first newcomers will be a few species with wind or bird borne seed well adapted to growing on bare sites usually quick growing (*Anthocephalus*, *Terminalia myriocarpa*) and often of limited size and life (*Trema*, *Macaranga*). Of recent years, the exotics *Eupatorium* and *Lantana* with wind and bird carried seed respectively have invaded such clearings to an increasing extent altering and probably considerably delaying further succession. In some regions bamboos or reeds (*Ochlandra*) may massively occupy the vacant site.

In due course the forest cover will be restored and presumably gradual succession will lead to the local climax but in many areas with increase in population and reduction of available forest area, the cycle has inevitably shortened and such regrowth as has developed is again cleared. The end result is typically grass with a few scattered trees, and subject to annual fires, a fire preclimax savannah type.

Grazing.—Grazing is little practised in the wet tropical evergreen forest and is a factor of no importance in it. In all other types, however, it has become a factor comparable only with fire in its far-reaching effects on the forests. Grazing also has an indirect effect on the standing trees in that associated with it are the practices of lopping for fodder and burning both to reduce the density of the woody cover and to induce grass growth. The vital direct effect is in the inhibition of regeneration. In many types at certain seasons when the supply of green herbage is low, all kinds of stock will browse and graze down any green tree seedlings that may be available (sal, *sissu*, *Adina*, *Abies*) and if the grazing is heavy or prolonged complete elimination takes place. In the shrub stratum grazing is concentrated on the palatable species (e.g. *Adina*, *Terminalia tomentosa*) which will again be completely eliminated unless they are sufficiently thorny as in the cases of *Zizyphus* and many *Acacias*. Thus as with fire, so grazing also results in a marked reduction in number of species and thereby a distinct alteration in the general morphology of the type. As, however, grazing and burning almost always go together, no biotic *grazing preclimax* has been described, although some subtypes of dry deciduous and thorn scrub types should probably be so described. In the semi-desert tracts of Rajasthan such scrub preclimaxes prevail where a close dry deciduous forest dominated by *Anogeissus pendula*, or *Acacia senegal* is clearly the climax still surviving in some of the hunting reserves of the former rulers.

CHAPTER IV

SYSTEM OF CLASSIFICATION OF VEGETATION TYPES

As vegetation develops in relation to and exists in balance with its total environment, the various attempts to classify it could be grouped according to the chief criteria used These might be the properties of the vegetation itself, the various climatic zones in which particular classes of vegetation are expected to flourish, or finally, the properties of the mature eco-system comprising the vegetation-environment complex and reflecting the interrelations of these elements. Systems may, however, also be built around more than one of these groups of factors, but the primary or the chief basis of classification can be easily distinguished. Different classifications are intended to fulfil various needs and may be equally valid. In the following discussion, the main approach, whether botanical, climatic or ecological, has been taken as the criterion for classifying these classifications themselves.

As has already been pointed out earlier, the need for classification of vegetation in the context of forestry arises from the fact that particular silvicultural and management practices are broadly correlated with and relevant to particular forest "types" and a rational workable system of classification of forest vegetation makes it possible to apply and evolve these practices in a controlled scientific manner. Hence the forester's special interest in a system of classification which places adequate emphasis on the structural—functional aspects of plant communities.

(a) Classifications based mainly on Vegetation

Classification of vegetation can be approached from the study of plant communities, the data being grouped in any of the several categories such as physiognomy, structure composition and dynamics.

The data may be broken down into successively smaller units on the basis of differences or aggregated into successively larger units on the basis of similarities. In the one case, the primary units are the plant associations, a number of which are assembled into a formation or type; in the other case, a series or formation is sub-divided in stages into the constituent associations. The Braun-Blanquet system, much used in Europe, and for studies of vegetation units of a rather small and restricted extent in India, is an example of the former, whereas the system of BEARD (1944), FOSBERG (1958) and WEBB (1959) typify the, latter approach.

BEARD's 1944 classification, as finally elaborated in 1955, starts with a floristic grouping (association) such as *Schima-Bauhinia*, which he assembles into physiognomic groups (formations), e.g. deciduous seasonal forest, which are further grouped according to habitats (formation series) e.g. the montane formation series. Although the process is synthetic, starting from the lowest recognizable units and building up into larger groups, the resultant classes are very similar to those adopted in the present study, with a few exceptions such as the differentiation of 'rain forest' from 'evergreen seasonal forest'. This is due to his concept that the rain forest occupies a unique central position as a formation as well as a formation-series and from it radiate habitat groups in descending order from optimum to pessimum. The optimum (Rain forest) and Seasonal formations are predominantly climatically determined whereas the Seasonal Swamp and Swamp formations are edaphically conditioned. The intermediate groups of Montane and Dry evergreen exhibit the operation of both series of factors, essentially climatic in the first case, and largely edaphic in the other.

FOSBERG (1958) puts forward a rational general classification of vegetation for the humid tropics based entirely in its higher units on Structure and Function, the ultimate units being inevitably floristic. Starting from a primary 'great structural group' based on spacing, the next level is called a 'formation class' (forest, scrub, savannah etc.), and 'formation group' (evergreen, deciduous etc.); 'formation' (rain forest, bamboo forest etc.) 'sub-formation' (mesophyll, megaphyll etc.) follow in descending order. It should be possible to fit any and every sample of vegetation into one of his units, but the scheme is quite inadequate to meet practical requirements since all evergreen rain forests and all deciduous (monsoon) forests are included, each in a single category, with no provision for anything between. FOSBERG has thus attempted a purely 'vegetational' classification but for practical purposes, as already stated, this strict limitation carries many disadvantages with it. Though the scheme is excellent for descriptive purposes, it obscures the relationship between a stable type and its derivatives and arrested stages due to biotic influences such as fire.

WEBB's 1959 classification is physiognomic and essentially similar to BEARD's. It deals, like the latter, only with climax types, in this case only the rain forests.

(b) CLASSIFICATIONS BASED MAINLY ON CLIMATE

The classifications based on climate are the most numerous. SCHIMPER (1898) classified first into temperature zones and within each of these he ascribed primary importance to moisture conditions; he considered mountains separately as having their own climatic peculiarities. He arranged the vegetation types of his tropical zone in a series with decreasingly favourable moisture conditions as follows :—1. Rain forest, 2. Monsoon forest, 3. Savannah, 4. Thorn, 5. Tropical grassland, 6. Tropical desert. A rainfall exceeding 2,000 mm. is suggested as resulting in rain forest.

MAYR (1909) similarly adopted temperature zones as the primary sub-division but combined latitude and altitude. He stressed the greater importance of mean temperature during the growing season (May to August) and emphasized the essential differences between coastal and continental climates, mountain climate tending to parallel the coastal type. In so far as his scheme concerns India, mention may be made of his sub-tropical zone, in which he includes the forests of Himalayan oaks, conifers, and evergreen *Magnolias* occurring between 1,220 m. and 2,150 m. The forests above 2 150 m. he includes in his

Castanetum, mentioning deciduous *Magnolias, Prunus, Pinus wallichiana* and *Cedrus deodara.* Himalayan forests above 2,440 m. in the east and 2,000 m. in the west are included in his *Fagetum.*

RUBNER (1925) similarly classified climates according to the number of months during which the mean monthly temperature exceeds a certain value—actually 10°C.

An important advance in the study of climate and vegetation was made by KOPPEN (1931). He distinguished eleven main climatic zones on temperature, rainfall and season of the latter. He used primarily the temperature of the hottest and coldest months and the relative rainfall of the wettest and driest months. This classification is, however, based more on reactions of vegetation with climate than on meteorological data. The chief climatic factors mentioned above are expressed by means of symbols combined into a climatic formula.

THORNTHWAITE (1933) differentiated thermal zones on a basis of "temperature efficiency" (T.E.) with numerical values for a T.E. index obtained by summing the 12 monthly indices each derived from the formula $\frac{1}{4}(T^{\circ}(F)\text{-}32)$ and classified in geometrical progression, from zero for perpetual frost to over 128 for the tropical zones. On this basis the whole of the Indian Peninsula and Plains are tropical; thus the T.E. index for Allahabad in Lat. N 15½° is 137¾. The values for Ootacamund (2,210 m., S. India) and Simla (2,148 m., N. India) are 66½ and 68¾ respectively, and fall at the bottom of his mesothermal zone with T. E. index from 64 to 127. His microthermal zone would be reached at about 2,300 m., for example at Darjeeling with a mean annual temperature of about 10.6° C and a T.E. index of 57. Dehra Dun (618 m.) with an index of 117 would be included as mesothermal with most of the hill stations of India, which is quite inacceptable on a vegetational basis.

Effectiveness of precipitation based on an empirically determined Precipitation Evaporation ratio, led him to differentiate on the basis of the reasonably well defined range of this index, five generally recognized physiognomic vegetation types, *viz.*, Rain Forest, Forest, Grassland, Steppe and Desert. Variations in seasonal distribution of the rainfall in relation to temperature and growing season also clearly produce superimposed effects. THORNTHWAITE finishes up with 50 vegetation types expected under given conditions of temperature, P.E. and seasonal distribution of rainfall. Unfortunately the predictions do not fit very well with what we actually find in India.

THORNTHWAITE's (1948) later formula involving the evaluation of *Potential Evapotranspiration* may be considered here rather than under bioclimatic methods. Although evapotranspiration naturally depends on the variety, density, life form and stage of growth of vegetation, he uses the concept of potential evapotranspiration, under unlimited supply of moisture, the value being independent of the nature of vegetation. It has been used by various workers for determining the climatic types of India, the latest map in the series being that prepared by SUBRAHMANYAM (1956). This also is not very satisfactory, the actual climatic characteristics of many stations departing significantly from THORNTHWAITE's types. On the whole, however, it fits the distribution of vegetation types better than those mentioned earlier. It may, however, be said with TURNER (1961) that the complex nature of the relationships between evaporative processes and plant behaviour remain to be worked out and that attempts to picture relationships between evaporation and forest types must necessarily be painted with a broad brush.

SHANBHAG (1958) has evolved a method of differentiating humid and arid climates based on thermodynamic principles, especially the relation between rise in temperature and speed of chemical reaction and on the supposition that 30°C marks a critical boundary below which growth stimulating factors are dominant and above which inhibiting factors come into play. This specially recognizes the role of high temperatures in limiting active growth. The resulting map shows the dry climatic zones more or less satisfactorily.

EMBERGER's (1955) formula for bioclimatic types

$$Q = \frac{P \times 100}{\frac{(M+m)}{2} \quad (M-m)}$$

where P is precipitation in mm., M the average maximum temperature of the hottest month and m the average minimum temperature of the coldest month in degrees centigrade, has been used by SETH and KHAN (1959) but instead of plotting 'Q' against m they plot it against 'm $(M-m)$'. Only the dry zones have been shown in their map of India in which four Northern continental types and five Southern peninsular types have been distinguished with reference to the line joining the intersection of the axes by the lines $Q=22$ and m $(M-m) = 400$. The extension of the Southern types well above the tropic in the western portion is brought out but otherwise there is no significant correspondence with existing vegetation.

The importance of the seasonal distribution of rainfall has been emphasized by SETH (1960) in his analysis of climatic types in the dry zone of India. The product of number of rainy days and rainfall are separately computed for the summer and winter seasons and plotted on coordinate paper to yield an *Isopluviogram* on which annual rainfall classes are distinguished on the basis of the relative importance of summer and winter precipitation patterns. Detailed comparison with vegetation types has, however, not been attempted.

In the same class, the climatic indices proposed by SCHMIDT and FERGUSSON (ratio of dry to wet days) and GINDEL (rainfall × rainy days, divided by evaporation) may also be cited.

GAUSSEN's (see 1959) system of differentiating bio-climatic types on the temperature, rainfall and duration of the dry period(s) also belongs to this group. Bioclimatic types have been differentiated for India and although correlations are established with the soil and vegetation types, and *plesioclimax* (*i.e.* the 'steady state' expected to be attained under conditions of no interference in a period of 100 years or so), the primary emphasis is on moisture availability as conditioned by the climatic pattern. Names have been assigned to bioclimates thus differentiated but terms such as "attenuated thermo-xerochimenic" are unlikely to be adopted in practical use. The bioclimatic maps of GAUSSEN, LEGRIS and VIART (1961) in process of being extended to cover the whole of Indiá will none the less be of permanent value to ecologists.

Finally recent attempts, notably those of WECK (1955) and PATERSON (1956) to assess the productivity of forests on the basis of climatic factors may be mentioned. It is assumed that the total (optimal) productivity is a function of light, temperature and moisture conditions which are climatically determined, and as a 'climax' is taken to be a steady state in which maximum productivity is maintained in relation to the factors of environment, it follows that productivity indices may show reasonable correlation with climax types. Revised climato-isophytes (lines joining points of equal productivity) prepared from the latest data according to PATERSON's method show good agreement with the limits of distribution of the arid, dry and moist forest belts; in fact there is reasonably good correlation between certain climato-isophytic zones and the occurrence of stabilized forest type like Thorn forest, Dry and Moist Teak, Moist Peninsular Sal, etc.

PATERSON's formula is

$$I = \frac{Tv}{Ta} P \times \frac{E}{100} \times \frac{G}{12}$$

Where (i) Tv is Mean Temperature of hottest month in °C.

(ii) Ta is difference between Mean Temperature of the hottest and the coldest month.

(iii) P is annual Precipitation in millimetres.

(iv) E is Evapotranspiration Intensity (evaluated from Milankovitch's equation, being the radiation at the pole as % of that at the latitude of the station).

(v) G is Growth Period in number of months (for cold climates, the number of months with a mean temperature equal to or higher than 3°C; for warm climates, humid months with de Martonne's aridity index $\frac{12P}{T+10}$ exceeding 20).

(i) and (ii) account for heat, (iii) for humidity, (iv) for potential evapotranspiration and (v) for length of growing season; these factors conditioning the vegetation as well as its potential productivity, for a region.

The inadequacy of purely climatic formulae in delimiting vegetation types is apparent because as pointedly observed by BEADLE (1951) the development of vegetation is also governed by the availability of species and their special adaptations, quite apart from interactions between plant life and environment. Thus because of the special nature of adaptations of the *Eucalyptus* genus to arid habitats, as against *Picea* which is much better adapted to cold conditions, the tree-line at similar latitudes in Australia and North America is at about 2,000 metres and 3,000 metres respectively.

(c) CLASSIFICATIONS BASED MAINLY ON ECO-SYSTEM

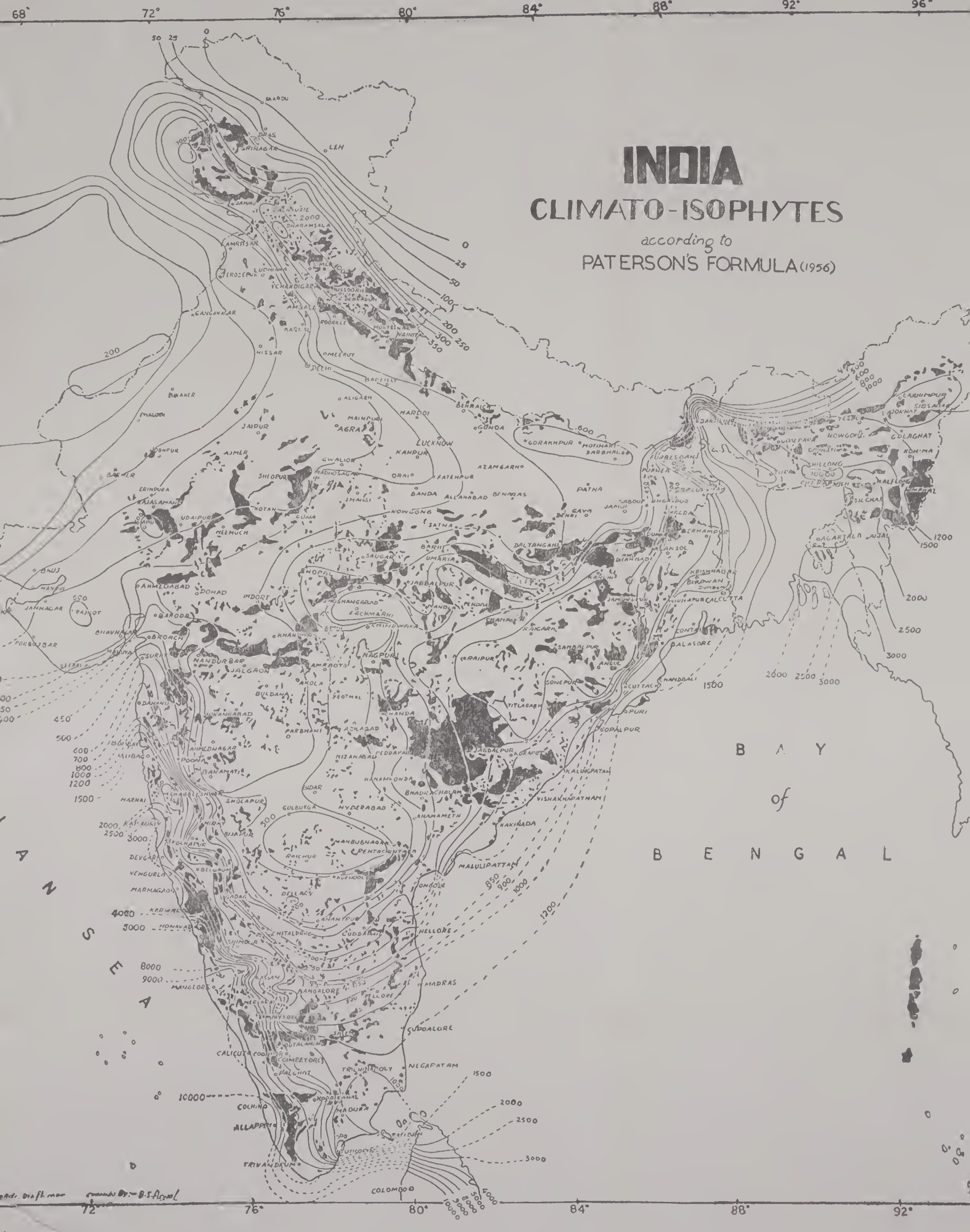
Important classifications which give sufficient weightage to both vegetational and climatic factors are few, the most notable being those of BURTT-DAVY, SWAIN and GAUSSEN. The classification used in the present work, both in the original and in the revised version, also belongs to this type.

BURTT-DAVY (1938), having a very wide knowledge of African vegetation, was of opinion that disregarding floristic differences, it should be possible to draw up a classification of general application to tropical forests that would meet the facts and requirements better than those of SCHIMPER and WARMING. A classification based largely on African experience and on CLEMENT's theory of succession had already been published (TANSLEY and CHIPP, 1926). BURTT-DAVY's greatest difficulty was to coordinate the extensive open grassy "savannah" types of Africa with their counterpart in Asia, the conclusion reached being that only the Tropical Dry Deciduous type of our Preliminary Classification could be approximately equated with it. His main divisions ('formations') are in close agreement with the 1936 proposals for India being independent of floristics, but he treats swamp and littoral types as *Moist Edaphic formations* with status little inferior to that of his *Moist climatic formations.*

SWAIN's (1938) classification evolved for Australia has been tested but does not seem to be wholly applicable to other regions. Thus KOELMEYER (1957-58) dealing with forest types of Ceylon essentially similar to those in parts of India, concludes that although it expresses the distribution of vegetation in Ceylon more satisfactorily than either the KOPPEN or 1931 THORNTHWAITE classification, there are reasons to doubt the validity of the limits used to separate various zones. He finds that the 1948 THORNTHWAITE classification expresses the vegetational patterns more effectively than others.

KUCHLER's (1949) system is based on life forms and KOPPEN's climatic types with letters as symbols for various groups to facilitate mapping. There does not seem to be a necessarily valid relation between the vegetation types and the climatic categories under which they have been brought together.

PURI (1960) whilst accepting in the main the preliminary classification put forward for India in 1936 and here under revision, revises it in several respects which call for consideration. He considers that there is no justification for separating the northern and southern variations of the major types as in his view the differences might be due to biotic or edaphic features and that vegetation changes occur more in an east-west direction : this is not in line with the facts and so is not acceptable. He also assumes that the characters of the dry deciduous thorn and dry evergreen types are ascribable to biotic factors, and not to climatic differences : this assumption is also not acceptable, although it can at once be accorded that several of the characters in question are generally accentuated by biotic factors, and the area occupied by these types has been widely extended by their action. He also prefers to transfer types treated as recognizable



INDIA

CLIMATO-ISOPHYTES

according to
PATERSON'S FORMULA (1956)

stages in the primary sere to his category of edaphic pre-climaxes. This is largely a question of nomenclature depending on the weightage given to the largely unknown time factor in successional change, but some of the types in question are being put in a separate category of Swamp forests in this revision. Finally there is a differentiation of subsidiary from primary edaphic types which is difficult to follow, and of biotic types still more difficult to distinguish from the secondary edaphic group.

CHAPTER V

THE REVISED CLASSIFICATION

BOURNE (1934) in a review of the provisional classification expressed his conviction that some of the type accorded climax status owed their existence entirely to biotic factors. On further consideration of this possibility, the conclusion has been reached that he has gone too far in generalizing from the particular in arguing for example that because a certain type of deciduous forest has demonstrably been derived from an evergreen one, all deciduous forest in the same climatic region must have originated this way. On the other hand, it is easy to go over with him and many other ecologists to the polyclimax theory according to which under any given climatic regime there may exist a number of climaxes, one for each major site type. In the extreme case such as on a sterile quartzite rock, it appears impossible for vegetation to progress to the same conditions as prevail on a fertile soil derived from igneous rock, no matter how much time is allowed, and a strictly monoclimax theory becomes untenable, but many intermediate positions are possible. The case of mangrove forest has already been mentioned; it is unquestionably seral so that to call it climax is a contradiction, and yet it appears stable. On the whole it would appear that neither the mono- nor the polyclimax theory entirely fits the known facts regarding the distribution of vegetation units and their stability in space and time, and the available evidence would best accord with 'climax' vegetation considered as a pattern of populations corresponding to the pattern of environmental gradients, occurring as a partially stabilized 'steady state'. The concept has been admirably dealt with by WHITTAKER (1953). In distinguishing the types in the present revised classification sufficient weightage has been given to this view.

BURTT-DAVY (1938) and others have objected to the use of the term "temperate" for the montane forests of the tropics on the grounds that the similarity is restricted to the temperature regime and does not extend to the different light conditions nor the typical monsoon climate of most tropical mountains. Whilst fully recognizing these differences, there appears to be little justification for forcing this point.

There has naturally also been criticism of the use of mixed criteria. As has been indicated, a good part of this is more apparent than real and can fairly be attributed to the lack of suitable terms, *i. e.* it could largely be avoided by substituting either cumbrous paraphrases or, even worse, the newly-invented adjectives of various ecological writers. Where this excuse is not valid, that of the maximum convenience of those for whom the book is written, with a minimum of likelihood of misunderstanding, is offered. As further studies are made, it will become possible to correct, improve and extend this still provisional scheme.

Taking into account the additional information now available and the comments made on the 1936 Preliminary Classification, it has been decided that there is little to be gained from making any large changes either in form or nomenclature. Accordingly the original framework is retained and the only significant change in arrangement has been to bring together the types associated with sites in which the soil is subject to excessive wetness either continuously or for periods long enough to have a marked effect on the vegetation. In this we are following BEARD and other authors. These types in question were classified before as stages in primary seres.

At the same time, all the types set up have been critically re-examined in the light of all available data to recognize the nature and extent of the effects of the biotic factors which unquestionably have influenced practically all of them. This scrutiny has resulted in the transfer of several from climax status to that of stages in secondary seres, or to a new category of degradation stages.

DEGRADATION STAGES

Forests, whether of climax status or at any stage in primary or secondary seres are liable to be degraded to varying degrees through biotic influences, notably excessive grazing, lopping for fodder, green manure or fuel, and unregulated fellings (often after girdling) for timber, poles and fuel. Such action is often selective being concentrated on the species most valued for the several purposes, not rarely to the extent of virtual elimination of the desirable species, but bearing lightly on the unpalatable ones and those least acceptable as timber or fuel; seedling stages are particularly exposed to extermination. The process is also influenced by the very varying powers of resistance of individual species to these treatments enabling the hardiest at least to survive whilst the more susceptible are exterminated. Thus in the *Quercus incana* type exposed to these adverse influences, the exceptionally hardy oak itself persists when all its associates except *Rhododendron arboreum* and *Lyonia ovalifolia* have been killed out, these two species also persisting as they are not eaten by cattle and are of very poor fuel value. In the extreme case, even the oak may succumb, leaving an open pure stand of *Rhododendron*. Over-grazing and tree destruction being usually combined, all trees may be eliminated—and with them often all possibility of natural regeneration— and shrub formations are left, being typically of a few unpalatable (*Adhatoda, Skimmia*) or thorny (*Carissa, Zizyphus*) species. Sometimes, one or more tree species have been preserved owing to their special value for human food or cattle fodder from the general damage or destruction. Thus *Madhuca* has very generally been spared in C. India whilst *Acacia leucophloea* and *Prosopis spicigera* 'standards' are often preserved for lopping over low scrub of *Zizyphus*, etc. and *Quercus dilatata* similarly in the hills. Scrub formations may be maintained for long periods if the grazing incidence remains heavy but not so much so as to destroy them in turn. As large areas of this kind are associated with the majority of the climax types to be considered, it is necessary to differentiate and describe the more characteristic of them. They will be described as "Degradation Stages" or DS.

Degradation of the vegetation will always be accompanied by a degree of exposure and desiccation of the site to the disadvantage of the more mesophytic species and regeneration by seed. The process will be reversed if protection is extended to degraded types and they will develop as secondary seres. *Pinus wallichiana* has in this way often colonised scrub land which originally carried coniferous or broadleaved forest; *Pinus roxburghii* has similarly invaded degraded forests which must have originally been evergreen oaks or mixed coniferous and dry deciduous trees.

(a) APPLICABILITY

The classification given on p. 48 must be prefaced by a few general remarks to prevent an unjustifiably rigid interpretation. The vegetation is determined by a great many factors simultaneously at play and all attempts at a formula for an arrangement in a single series have failed to meet requirements. After such obvious limiting factors as frost, longlying snow, fresh and saltwater inundations etc., have been excluded, moisture conditions during the growing season are evidently the most important item in determining the type of vegetation which can exist; but neither rainfall alone nor atmospheric humidity indicates the availability of the moisture for growth, many other factors among which the soil is predominant also coming into play. In this way, the familiar 2,000 mm. rainfall limit for rain forest, whilst correct in a very general way, is open to the exceptions of the occurrence of the type with only 1,250 mm. of rain under very favourable conditions and its absence with even 5,000 mm. unsuitably distributed when it is associated with either a very porous or an impervious soil. The figures given for rainfall, temperature and altitude refer accordingly only to the typical occurrences and will only be applicable to individual habitats when other conditions, notably distribution of rainfall, soil and aspect, are near the average. Beyond this stage, the vegetation itself is a better integration of the climatic conditions than any available numerical data. It has already been mentioned but needs to be stressed that whereas the greater part of the forests can be allotted fairly easily to one or other of the types differentiated, a considerable area is naturally occupied by transitional forms (cf. Plate 70). Over restricted tracts, such transitions may predominate as also where topography and soil are very variable, but the classification will still be fulfilling its intended purpose if it is possible to indicate the types compounded in the transition. The gradation between luxuriant tropical evergreen forest and mainly deciduous types is very complete, but for practical purposes recognition of intermediate stages is essential.

(b) THE MAJOR GROUPS

TROPICAL FORESTS

As has been seen above, most authorities agree in subdividing the vegetation of the tropical zone on a basis of moisture conditions, into a series of successively drier climatic types as follows :

Evergreen forest; Deciduous forest; Savannah; Thorn forest; Steppe.

In India it seems very doubtful if there are any examples of tropical climax grassland, though grassland is common enough as a secondary seral stage and it may be a stable 'preclimax' under the influence of fire and grazing.

The typical climax savannah type of other countries is also apparently absent, closed deciduous forest grading in to thorn forest without any open grassy park-like stage in the absence of biotic influences; on the other hand 'savannah' as a degradation stage is fairly frequent. The term 'savannah' applied to climate is however, used by KOPPEN and others for all tropical climates with a definite dry season, whatever the nature of the vegetation.

A study of the climates and forests of India leaves one with the conviction that whilst some differences can be found between the tracts north and south of the Tropic of Cancer, they are much less striking than the resemblances, and this uniformity is seen in floristic composition as well as in growth form. It is, therefore, unreasonable to make any primary subdivision of the land south of the Himalayas on a basis of latitude or temperature for distinguishing the main type-groups, though this is a useful step as a later stage, the more so, the moister the type.

The following seven type-groups are recognised:—

TROPICAL FORESTS

1. *Wet evergreen forests*	Dense tall forest, entirely evergreen or nearly so.
2. *Semi-evergreen forests*	Dominants include deciduous species but evergreens predominate.
3. *Moist deciduous forests*	Dominants mainly deciduous but subdominants and lower storeys largely evergreen. Top canopy rarely dense and even, but over 25 m. high.
4. *Littoral and swamp forests*	Mainly evergreen, of varying density and height, but always associated predominantly with wetness.
5. *Dry deciduous forests*	Entirely deciduous or nearly so. Top canopy rather light and rarely over 25 m. high, usually 8-20 m.
6. *Thorn forests*	Deciduous with low thorny trees and xerophytes predominating. Canopy more or less broken. Height under 10 m.
7. *Dry evergreen forests*	Hard leaved evergreen trees predominate with some deciduous emergents, often dense, but usually under 20 m. high.

All these main type-groups of tropical forest except the fourth and the last can be sub-divided into southern and northern forms, the difference becoming less obvious the drier the type. The difference is to some extent in form, but largely floristic. The dry evergreen forest is restricted to the S. E. of the Peninsula.

Certain types determined by special site factors have such pronounced characteristics as to require separate treatment independently of the main climatic types, though ecologically they may be viewed as stages in natural successions or as edaphic preclimaxes. They have been brought together for convenience under category 4 above, and comprise :—

A. *Littoral forests*	On coastal sand, usually seral to 1 or 2 and somewhat resembling 2.
B. *Tidal swamp forests*	On estuarine mud, seral to any of the other types.
C. *Freshwater swamp forests*	On wet alluvium, seral to 1-3 or 5 and resembling 2.
D. *Seasonal swamp forests*	On alluvium in which the seasonal submersion is the dominant influence although the soil may become relatively dry for part of the year.
E. *Riverain fringing forests*	Along stream sides where subsoil water is available throughout the year.

These forests are predominantly evergreen though often more or less xerophytic owing to physiological dryness; the riverain fringing forest includes a varying proportion of deciduous species and is in a sense transitional to dry land types, though floristically it comprises a number of characteristic species.

MONTANE SUBTROPICAL FORESTS

In India, subtropical temperatures are determined more by altitude than by latitude and are characteristically developed in the hilly tracts. There is no major change in the vegetation north and south of the Tropic of Cancer nor at any higher latitude before the foot of the Himalayan Range. The subtropical zone is accordingly most conveniently considered as transitional from the tropical to the temperate zone and is sometimes hardly distinguishable either in form or composition from one or the other. With a moderate summer monsoon rainfall, it seems quite well defined in the West and Central Himalayas as the *chir* pine belt, whilst with a low rainfall largely in the winter a fairly characteristic subtropical dry evergreen forest is developed in the plains and low hills of the N.W. With a heavier summer rainfall, a subtropical belt is still apparent in the East Himalayas between the tropical vegetation and the temperate oak forest : in Assam the tendency for the oak forests to extend right down without a break is even more marked and makes differentiation almost impossible. In the South Indian hills, there seems to be no real break between tropical and definitely temperate types, only a falling off in the luxuriance of the forest. Floristic changes are discernible but there is no characteristic subtropical flora, only an overlap of predominantly tropical and predominantly temperate floras. The small range of daily and seasonal temperature characteristic of regions near the equator evidently comes into play here, and the floristic differences are traceable to the past history of plant migration. With relatively low rainfall, the tropical deciduous type extends right up to the temperate evergreen — thus sal overlaps *ban* oak.

The following three main type-groups are recognised:—

1. *Subtropical broadleaved hill forests*	(Southern and Northern forms). Broadleaved largely evergreen high forest.
2. *Subtropical pine forests*	Pine associations predominate.
3. *Subtropical dry evergreen forests*	Low xerophytic forest and scrub.

Except for occasional landslips and narrow strips of alluvium, new ground rarely occurs, so that degradation stages are commoner than seral ones. Secondary seres take the savannah form.

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Montane Temperate Forests

The South Indian hills differ markedly and significantly from the Himalayan area in the small annual range of monthly mean temperature, which is under 8° C (only 19° to 23°, or 4° C, at Mahabaleshwar, at 1,378 m., and 13° to 19° C or 6° C, at Wellington at 1,890 m.), as compared with 9°C or considerably more for the latter (Ranikhet at 1,859 m. range 8° to 22° or 14° C, and Shillong at 1,491 m., range 4° to 16° or 12° C). The distribution of rainfall in the South is also different, reaching its maximum in October instead of June or July, but all the stations for which records are available have a 3 or 4-month dry winter period with a monthly rainfall of less than 50 mm. (e.g. Darjeeling, Shillong, Ootacamund), falling rather earlier to the North and West than in the South and East; this latter difference would hardly affect the nature of the vegetation.

The northern montane temperate forests seem to be best classified by the rainfall during the season of vegetative activity which may be taken as roughly the months with mean temperature over 13°C. Three stages are distinguishable, two of them mainly coniferous, though broadleaved trees (either evergreen oaks or mixed deciduous species) are often associated with the conifers, only the wettest type being predominantly broadleaved evergreen.

Three type-groups are recognised:

Montane Temperate Forests

1. *Montane wet temperate forests*	Evergreen forest without conifers.
2. *Himalayan moist temperate forests*	Evergreen forest, mainly sclerophyllous oaks and conifers.
3. *Himalayan dry temperate forests*	Open coniferous forest with sparse xerophytic undergrowth.

The montane wet temperate forest occurs in markedly different northern and southern forms, whilst the others occur only in the Himalayas but differ considerably according as to whether the conifers or the broadleaved trees predominate. As in the montane sub-tropical zone, primary and secondary seres are of small extent though degradation stages may cover large areas. Soil variations determine both the detailed distribution of associations and the balance between drier and moister types, but rarely result in the development of markedly different types.

Alpine conditions are only met with in the Himalayas and connected ranges. Above the timber limit, high forest is replaced by alpine scrub varying in form with the available moisture supply.

SUB-ALPINE FORESTS

1. *Sub-alpine forests*	Stunted deciduous or evergreen forest usually in close formation with or without conifers.

ALPINE SCRUB

1. *Moist alpine scrub*	Low but often dense scrub.
2. *Dry alpine scrub*	Xerophytic shrubs in open formation.

REVISED CLASSIFICATION OF INDIAN FOREST TYPES

I— MOIST TROPICAL FORESTS

GROUP 1—TROPICAL WET EVERGREEN FORESTS

Sub-group 1A—Southern tropical wet evergreen forests :

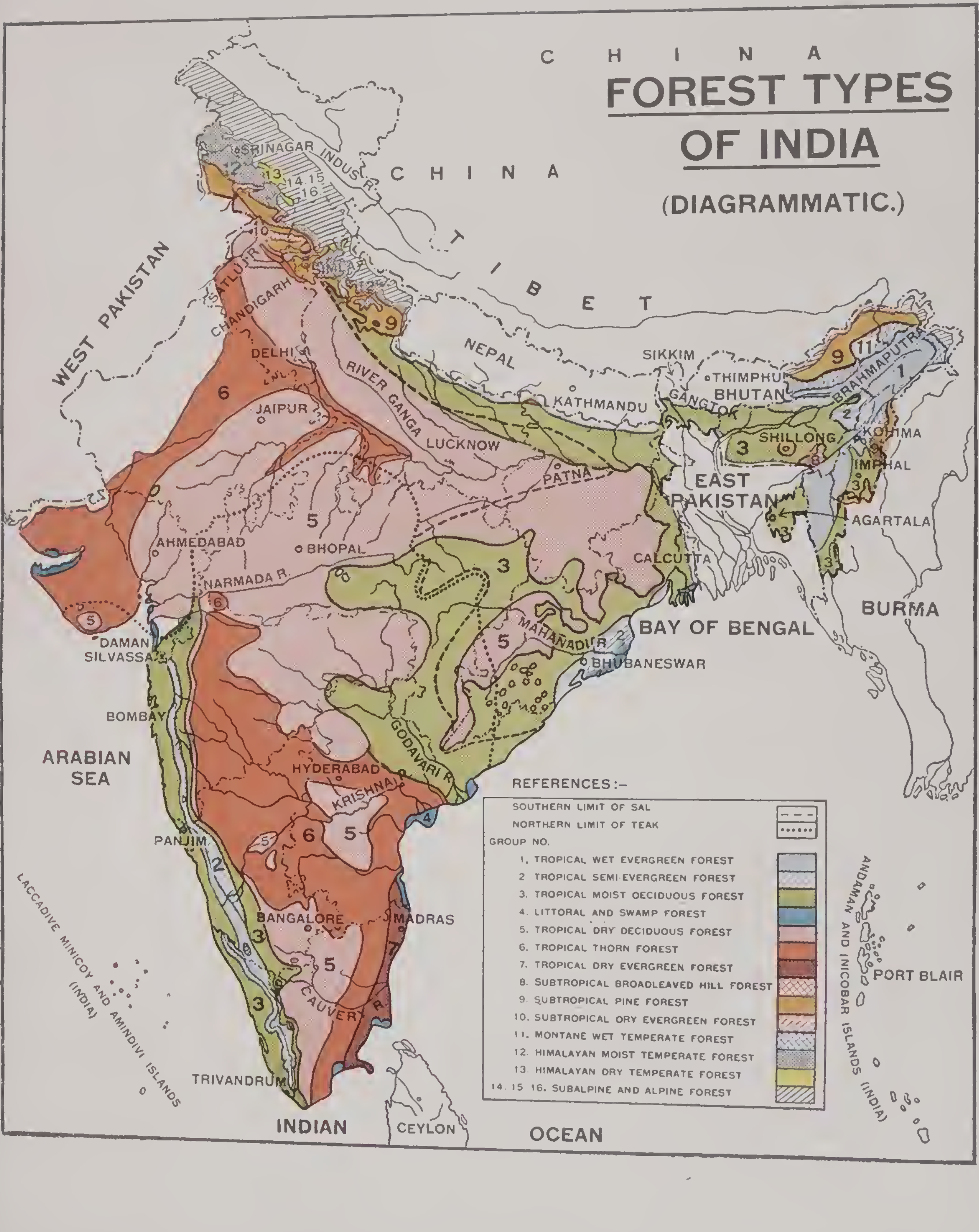
C1	(Giant evergreen forests)	(P. 62)
C2	Andamans tropical evergreen forest	(P. 63; Pls. 1, 2)
E1	(Andamans moist deciduous forests)	(P. 64)
C3	Southern hilltop tropical evergreen forest	(P. 64)
C4	West Coast tropical evergreen forest	(P. 65 ; Pls. 3, 4, 5)

Sub-group 1B—Northern tropical wet evergreen forests :

C1	Assam Valley tropical wet evergreen forest (*Dipterocarpus*)	(P. 76; Pl. 6)
C2	Upper Assam Valley tropical evergreen forest	(P. 77)
	(a) *Kayea* forest	(P. 77)
	(b) *Mesua* forest	(P. 77)
C3	Cachar tropical evergreen forest	(P. 78)

General edaphic and seral types of wet evergreen forests :

E1	Cane brakes	(P. 79; cf. Pl. 33)
E2	Wet bamboo brakes	(P. 80; Pl. 7)
2S1	Pioneer Euphorbiaceous scrub	(P. 80; cf. Pl. 27)



FOREST TYPES OF INDIA

(DIAGRAMMATIC.)

CHINA
CHINA
TIBET
WEST PAKISTAN
NEPAL
SIKKIM
BHUTAN
EAST PAKISTAN
BURMA
CEYLON
ARABIAN SEA
BAY OF BENGAL
INDIAN OCEAN
LACCADIVE MINICOY AND AMINDIVI ISLANDS (INDIA)
ANDAMAN AND NICOBAR ISLANDS (INDIA)
SRINAGAR
INDUS R.
SIMLA
SATLUJ R.
CHANDIGARH
DELHI
JAIPUR
RIVER GANGA
LUCKNOW
PATNA
KATHMANDU
THIMPHU
GANGTOK
SHILLONG
KOHIMA
IMPHAL
AGARTALA
BRAHMAPUTRA
CALCUTTA
AHMEDABAD
BHOPAL
NARMADA R.
DAMAN
SILVASSA
MAHANADI R.
BHUBANESWAR
BOMBAY
GODAVARI R.
HYDERABAD
KRISHNA
PANJIM
BANGALORE
MADRAS
CAUVERY R.
TRIVANDRUM
PORT BLAIR
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14.15 16
REFERENCES:-
SOUTHERN LIMIT OF SAL
NORTHERN LIMIT OF TEAK
GROUP NO.
1. TROPICAL WET EVERGREEN FOREST
2. TROPICAL SEMI-EVERGREEN FOREST
3. TROPICAL MOIST DECIDUOUS FOREST
4. LITTORAL AND SWAMP FOREST
5. TROPICAL DRY DECIDUOUS FOREST
6. TROPICAL THORN FOREST
7. TROPICAL DRY EVERGREEN FOREST
8. SUBTROPICAL BROADLEAVED HILL FOREST
9. SUBTROPICAL PINE FOREST
10. SUBTROPICAL DRY EVERGREEN FOREST
11. MONTANE WET TEMPERATE FOREST
12. HIMALAYAN MOIST TEMPERATE FOREST
13. HIMALAYAN DRY TEMPERATE FOREST
14. 15 16. SUBALPINE AND ALPINE FOREST

GROUP 2—TROPICAL SEMI-EVERGREEN FORESTS

Sub-group 2A—Southern tropical semi-evergreen forests :

C1	Andamans semi-evergreen forest	(P. 85; Pls. 8, 9)
C2	West Coast semi-evergreen forest	(P. 85; Pl. 10)
C3	Tirunelveli semi-evergreen forest	(P. 87)
2S1	West Coast secondary evergreen *Dipterocarp* forest	(P. 87; Pl. 11)

Sub-group 2B—Northern tropical semi-evergreen forests :

C1	Assam Valley semi-evergreen forest	(P. 92)
1*a*	Assam alluvial plains semi-evergreen forest	(P. 92; Pl. 12)
1*b*	Eastern submontane semi-evergreen forest	(P. 94)
1S1	Sub-Himalayan light alluvial semi-evergreen forest	(P. 95)
1S2	*Syzygium* parkland	(P. 96)
2S1	(Pioneer Euphorbiaceous scrub)	(P. 96)
2S2	Eastern alluvial secondary semi-evergreen forest	(P. 96)
2S3	Sub-Himalayan secondary wet mixed forest	(P. 98; Pl. 13)
C2	Cachar semi-evergreen forest	(P. 99)
C3	Orissa semi-evergreen forest	(P. 100; Pl. 14)

General edaphic and seral types of semi-evergreen forests :

E1	(Cane brakes)	(P. 101)
E2	(Wet bamboo brakes)	(P. 101)
E3	Moist bamboo brakes	(P. 101; cf. Pl. 7)
E4	Lateritic semi-evergreen forest	(P. 102)
2S1	Secondary moist bamboo brakes	(P. 102)

GROUP 3—TROPICAL MOIST DECIDUOUS FORESTS

Sub-group 3A—Andamans moist deciduous forests :

C1	Andamans moist deciduous forest	(P. 103; Pls. 15, 16)
2S1	Andamans secondary moist deciduous forest	(P. 104; Pl. 17)

Sub-group 3B—South Indian moist deciduous forests :

C1	Moist teak-bearing forest	(P. 111)
1*a*	Very moist teak forest	(P. 112; Pl. 18)
1*b*	Moist teak forest	(P. 115; Pls. 19, 20)
1*c*	Slightly moist teak forest	(P. 116; Pl. 21)
C2	Southern moist mixed deciduous forest	(P. 117; Pl. 22)
2S1	Southern secondary moist mixed deciduous forest	(P. 119)

Sub-group 3C—North Indian moist deciduous forests :

C1	Very moist sal-bearing forest	(P. 127)
1*a*	Eastern hill sal forest	(P. 128)
(i)	East Himalayan sal	(P. 128)
(ii)	Khasi hill sal	(P. 130)
1*b*	Eastern *bhabar* sal forest	(P. 131)
(i)	East Himalayan upper *bhabar* sal	(P. 131; Pl. 23)
(ii)	East Himalayan lower *bhabar* sal	(P. 133)
1*c*	Eastern *tarai* sal forest	(P. 134)
1*d*	Peninsular (coastal) sal forest	(P. 135; Pl. 24)
C2	Moist sal-bearing forest	(P. 135)
2*a*	Moist Siwalik sal forest	(P. 136)
2*b*	Moist *bhabar* sal forest	(P. 137)
(i)	*Bhabar-dun* sal	(P. 137)
(ii)	*Damar* sal	(P. 138)
2*c*	Moist *tarai* sal forest	(P. 139)
2*d*	Moist plains sal forest	(P. 139)
(i)	Western light alluvium plains sal	(P. 139)
(ii)	App. *Chandar* sal	(P. 140)
(iii)	Eastern heavy alluvium plains sal	(P. 140)
(iv)	App. Kamrup sal	(P. 141)
2*e*	Moist peninsular sal forest	(P. 143)
(i)	Moist peninsular high level sal	(P. 143; Pl. 25)
(ii)	Moist peninsular low level sal	(P. 144)
(iii)	Moist peninsular valley sal	(P. 145)
DS1	Moist sal savannah	(P. 146)
C3	Moist mixed deciduous forest (without sal)	(P. 147)
3*a*	West Gangetic moist mixed deciduous forest	(P. 147; Pl. 26)
3*b*	East Himalayan moist mixed deciduous forest	(P. 149)
2S1	Northern secondary moist mixed deciduous forest	(P. 150)
2S2	(Secondary Euphorbiaceous scrub)	(P. 151; Pl. 27)

General edaphic and seral types of moist deciduous forests :

E1	*Terminalia tomentosa* forest	(P. 151)
1S1	Low alluvial savannah woodland (*Salmalia-Albizzia*)	(P. 152)
1S2	Eastern hollock forests (*Terminalia myriocarpa*)	(P. 154)
2*a*	*Terminalia-Lagerstroemia*	(P. 154; Pl. 28)
2*b*	*Terminalia-Duabanga*	(P. 154)
2S1	(Dry bamboo brakes)	(P. 155)

GROUP 4—LITTORAL AND SWAMP FORESTS

Sub-group 4A—Littoral forests :

L1	Littoral forest	(P. 155; Pl. 29)

Sub-group 4B—Tidal swamp forests :

TS1	Mangrove scrub	(P. 163)
TS2	Mangrove forest	(P. 164; Pl. 30)
TS3	Saltwater mixed forest (*Heritiera*)	(P. 165)
TS4	Brackish water mixed forest (*Heritiera*)	(P. 166; Pl. 31)
E1	Palm swamp	(P. 166; cf. Pl. 31)

Sub-group 4C—Tropical freshwater swamp forests :

FS1	*Myristica* swamp forest	(P. 167; Pl. 32)
FS2	Submontane hill valley swamp forest	(P. 167; Pl. 33)
FS3	Creeper swamp forest	(P. 168)

Sub-group 4D—Tropical seasonal swamp forests :

SS1	Eastern seasonal swamp forest	(P. 169)
SS2	*Barringtonia* swamp forest	(P. 169; Pl. 34)
SS3	*Syzygium cumini* swamp low forest	(P. 170; Pl. 35)
SS4	Eastern seasonal swamp low forest (*Cephalanthus*)	(P. 171)
SS5	Eastern *Dillenia* swamp forest	(P. 171)
2S1	(*Syzygium* parkland)	(P. 172)
2S2	(Eastern wet alluvial grassland)	(P. 172; Pl. 36)

Sub-group 4E—Tropical riparian fringing forests :

RS1	Riparian fringing forest	(P. 173; Pl. 37)

II—DRY TROPICAL FORESTS

GROUP 5—TROPICAL DRY DECIDUOUS FORESTS

Sub-group 5A—Southern tropical dry deciduous forests :

C1	Dry teak-bearing forest	(P. 180)
1*a*	Very dry teak forest	(P. 181; Pl. 38)
1*b*	Dry teak forest	(P. 182; Pls. 39, 40)
C2	Dry red sanders-bearing forest	(P. 185; Pl. 41)
C3	Southern dry mixed deciduous forest	(P. 185; Pl. 42)

Sub-group 5B—Northern tropical dry deciduous forests :

C1	Dry sal-bearing forest	(P. 194)
1*a*	Dry Siwalik sal forest	(P. 195; Pl. 43)
1*b*	Dry plains sal forest	(P. 196)
1*c*	Dry peninsular sal forest	(P. 198)
C2	Northern dry mixed deciduous forest	(P. 200; Pls. 44, 45)

Degradation stages of tropical dry deciduous forests :

DS1	Dry deciduous scrub	(P. 205)
DS2	Dry savannah forest	(P. 207)
DS3	(*Euphorbia* scrub)	(P. 208)
DS4	(Dry grassland)	(P. 209)

General edaphic types of dry deciduous forests :

E1	*Anogeissus pendula* forest	(P. 210; Pl. 46)
DS1	*Anogeissus pendula* scrub	(P. 212; Pl. 47)
E2	*Boswellia* forest	(P. 212; Pl. 48)
E3	*Babul* forest	(P. 214; Pl. 49)
E4	*Hardwickia* forest	(P. 215; Pl. 50)
E5	*Butea* forest	(P. 215; Pl. 51)
E6	*Aegle* forest	(P. 216)
E7	Laterite thorn forest	(P. 217)
E8	Saline/alkaline scrub savannah	(P. 218)
8*a*	*Phoenix* savannah	(P. 218; Pl. 52)
8*b*	*Babul* savannah	(P. 219)
8*c*	*Salvadora-Tamarix* scrub	(P. 219)
E9	Dry bamboo brake	(P. 220; Pl. 53)

General seral types of dry deciduous forests :

1S1	Dry tropical riverain forest	(P. 221; cf. Pl. 37)
1S2	*Khair-sissu* forest	(P. 222; Pl. 54)
1S3	Inundation *babul* forest	(P. 224)
2S1	Secondary dry deciduous forest	(P. 225)

GROUP 6—TROPICAL THORN FORESTS

Sub-group 6A—Southern tropical thorn forests :

C1	Southern thorn forest	(P. 229; Pl. 55)
C2	Karnatak umbrella thorn forest	(P. 232; Pl. 56)
DS1	Southern thorn scrub	(P. 233)
DS2	Southern *Euphorbia* scrub	(P. 233; Pl. 57)

Sub-group 6B—Northern tropical thorn forests :

C1	Desert thorn forest	(P. 239; Pls. 58, 59)
C2	Ravine thorn forest	(P. 240; Pl. 60)
DS1	*Zizyphus* scrub	(P. 242; Pl. 61)
DS2	Tropical *Euphorbia* scrub	(P. 242; Pl. 62)

General edaphic, degraded and seral types of thorn forests :

E1	(*Euphorbia* scrub)	(P. 243)	
E2	*Acacia senegal* forest	(P. 244; Pl. 63)	
E3	*Rann* saline thorn forest	(P. 244; Pls. 64, 65)	
E4	*Salvadora* scrub	(P. 244)	(Pl. 66)
DS1	*Cassia auriculata* scrub	(P. 245)	
1S1	Desert dune scrub	(P. 245; cf. Pl. 58)	

Group 7—Tropical Dry Evergreen Forests

C1	Tropical dry evergreen forest	(P. 246)
DS1	Tropical dry evergreen scrub	(P. 250)

III—MONTANE SUBTROPICAL FORESTS

Group 8—Subtropical Broadleaved Hill Forests

Sub-group 8A—Southern subtropical broadleaved hill forests:

C1	Nilgiri subtropical hill forest	(P. 254)
DS1	South Indian sub-tropical hill savannah (woodland)	(P. 255)
E1	Reed brakes (*Ochlandra*)	(P. 256; Pl. 67)
C2	Western subtropical hill forest	(P. 256)
C3	Central Indian subtropical hill forest	(P. 257; Pl. 68)
DS	(Degradation stages of Southern subtropical broadleaved hill forests)	(P. 259)

Sub-group 8B—Northern subtropical broadleaved wet hill forests:

C1	East Himalayan subtropical wet hill forest	(P. 260; Pl. 69)
C2	*Khasi* subtropical wet hill forest	(P. 265)
2S1	(Assam subtropical pine forest)	(P. 266)
DS1	(Assam subtropical hill savannah woodland)	(P. 267)

Group 9—Subtropical Pine Forests

C1	Himalayan subtropical pine forest	(P. 270)
1*a*	Lower or Siwalik chir pine forest	(P. 270; Pl. 70)
1*b*	Upper or Himalayan chir pine forest	(P. 272; Pl. 71)
DS1	Himalayan subtropical scrub	(P. 274)
DS2	Subtropical *Euphorbia* scrub	(P. 274; Pl. 72)
C2	Assam subtropical pine forests	(P. 274; Pl. 73)
DS1	Assam subtropical pine savannah	(P. 275)

Group 10—Subtropical Dry Evergreen Forests

C1	Subtropical dry evergreen forest	(P. 276)
1*a*	*Olea cuspidata* scrub forest	(P. 276)
1*b*	*Acacia modesta* scrub forest	(P. 277 ; Pl. 74)
DS1	*Dodonaea* scrub	(P. 277)

IV—MONTANE TEMPERATE FORESTS

GROUP 11—MONTANE WET TEMPERATE FORESTS

Sub-group 11A—Southern montane wet temperate forests :

C1	Southern montane wet temperate forest	(P. 278 ; Pl. 75)
DS1	Southern montane wet scrub	(P. 282 ; Pl. 76)
DS2	Southern montane wet grassland	(P. 282 ; Pl. 77)

Sub-group 11B—Northern montane wet temperate forests:

C1	East Himalayan wet temperate forests	(P. 286)	
1*a*	Lauraceous forest	(P. 287)	
1*b*	*Buk* oak forest	(P. 287)	(Pl. 78)
1*c*	High-level oak forest	(P. 288)	
C2	Naga hills wet temperate forests	(P. 288)	

GROUP 12—HIMALAYAN MOIST TEMPERATE FORESTS

C1	Lower Western Himalayan temperate forest	(P. 296)
1*a*	*Ban* oak forest (*Q. incana*)	(P. 296; Pl. 79)
1*b*	*Moru* oak forest (*Q. dilatata*)	(P. 299; Pl. 80)
DS1	Oak scrub	(P. 301)
1*c*	Moist deodar forest (*Cedrus*)	(P. 301; Pl. 81)
1*d*	Western mixed coniferous forest (spruce, blue pine, silver fir).	(P. 304; Pl. 82)
1*e*	Moist temperate deciduous forest	(P. 307; Pl. 83)
1*f*	(Low-level blue pine forest (*P. wallichiana*))	(P. 308)
DS1	Oak scrub	(P. 309)
DS2	Himalayan temperate secondary scrub	(P. 309)
C2	Upper West Himalayan temperate forest	(P. 310)
2*a*	*Kharsu* oak forest (*Q. semecarpifolia*)	(P. 310 ; Pl. 84)
2*b*	West Himalayan upper oak/fir forest	(P. 312)
2*c*	(Moist temperate deciduous forest)	(P. 314)
C3	East Himalayan moist temperate forest	(P. 314)
3*a*	East Himalayan mixed coniferous forest	(P. 315)
3*b*	*Abies delavayi* forest	(P. 316; Pl. 85)

Degradation stages of Himalayan moist temperate forests:

DS1	Montane bamboo brakes	(P. 316; Pl. 86)
DS2	Himalayan temperate parkland	(P. 317)
DS3	Himalayan temperate pastures	(P 318; Pl. 87)

General edaphic and seral types of Himalayan moist temperate forests:

E1	Cypress forest	(P. 318; Pl. 88)
1S1	Alder forest	(P. 319; Pl. 89)
1S2	Riverain blue pine forest	(P. 320; Pl. 90)
2S1	Low-level blue pine forest	(P. 320; Pl. 91)

GROUP 13— HIMALAYAN DRY TEMPERATE FORESTS

(i) *Western types*

C1	Dry broadleaved and coniferous forest (*Quercus ilex–P. gerardiana*)	(P. 325; Pl. 92)
C2	Dry temperate coniferous forest	(P. 325)
2*a*	*Neoza* pine forest (*P. gerardiana*)	(P. 325) } (Pl. 93)
2*b*	Dry deodar forest (*Cedrus*)	(P. 326)
DS1	*Pohu* scrub	(P. 327; Pl. 94)
DS2	Dry temperate scrub	(P. 327)
C3	(West Himalayan dry temperate deciduous forest)	(P. 327)
C4	West Himalayan high-level dry blue pine forest (*P. wallichiana*).	(P. 328)
C5	West Himalayan dry juniper forest (*J. macropoda*)	(P. 328; Pl. 95)

(ii) *Eastern types*

C6	East Himalayan dry temperate coniferous forest	(P. 328)
E1	Larch forest (*L. griffithiana*)	(P. 329)
C7	East Himalayan dry juniper /birch forest (*J. wallichiana*).	(P. 329)

General seral types of dry temperate forests:

1S1	*Hippophae/Myricaria* scrub	(P. 330; Pl. 96)
1S2	*Populus/Salix* forest	(P. 330)
1S3	(Western high-level dry blue pine forest)	(P. 330)

V—SUB-ALPINE FORESTS

GROUP 14—SUB-ALPINE FORESTS

C1	West Himalayan sub-alpine birch/fir forests (*Betula/Abies*)	(P. 334)
1*a*	West Himalayan sub-alpine fir forest	(P. 335) } (Pls. 97, 98)
1*b*	West Himalayan sub-alpine birch/fir forest	(P. 335)
C2	East Himalayan sub-alpine birch/fir forest	(P. 336; Pl. 99)

Seral and degraded types of sub-alpine forests:

1S1	(*Hippophae/Myricaria* brakes)	(P. 336)
1S2	(Deciduous sub-alpine scrub)	(P. 336)
2S1	(Sub-alpine blue pine (*P. wallichiana* forest))	(P. 336)
DS1	Sub-alpine pastures	(P. 337; Pl. 100)

VI—ALPINE SCRUB

Group 15—Moist Alpine Scrub

C1	Birch/*Rhododendron* scrub forest	(P. 338; Pl. 101)
C2	Deciduous alpine scrub	(P. 339; Pl. 102)
E1	Dwarf *Rhododendron* scrub	(P. 340; cf. Pl. 101)
E2	(Dwarf juniper scrub)	(P. 341)
C3	(Alpine pastures)	(P. 341)

Group 16—Dry Alpine Scrub

C1	Dry alpine scrub	(P. 341; Pl. 103)
E1	Dwarf juniper scrub	(P. 341)

CHAPTER VI

MOIST TROPICAL FORESTS

GROUP 1. TROPICAL WET EVERGREEN FORESTS

Sub-group 1A. Southern Tropical Wet Evergreen Forests

1. NOMENCLATURE

Maharashtra	Tropical evergreen rain forest.
Mysore *Madras* *Kerala*	Tropical evergreen (*Shola*).
Andamans	(Hill) Evergreen low forest (PARKINSON).

2. GENERAL DESCRIPTION

Lofty, dense, evergreen forests, 45 m. or even more high, characterised by the large number of species of trees which occur together. Consociations (gregarious dominants) are rarely met with and ordinarily two thirds or more of the upper canopy trees are of species individually contributing not more than 1 per cent of the total number; a few species, however, do occur semi-gregariously. Some species of the top storey are trees with clear boles 30 m. long and 5 m. or more in girth, and may be briefly deciduous without affecting the evergreen nature of the forest as a whole. The canopy is extremely dense; it has been demonstrated that apart from the scattered giants which project well above the general canopy, differentiation into definite canopy layers probably does not exist (RICHARDS). Epiphytes are numerous, especially aroids, ferns, mosses and orchids. Climbers vary greatly in amount being sometimes conspicuous but often not so; on the whole they are less characteristic than in the semi-evergreen and moist deciduous forests. Ground vegetation in typical cases may be almost absent; elsewhere a carpet of *Strobilanthes* or *Selaginella* and ferns may occur; grasses are absent. The undergrowth is often a tangle of canes, creeping bamboo and palms, which may replace high forest as cane brake along streams. Erect bamboos are unusual, but may occur locally. Long cylindrical boles usually with thin smooth bark are typical but plank buttresses are also frequently seen. The leaves are thick and glossy, only rarely finely pinnate or hairy, and are very often white or pink when young. Cauliflory may be relatively common.

3. DISTRIBUTION

Throughout the tropical portion of the country wherever the rainfall is adequate and its distribution satisfactory except on precipitous slopes and very rapidly draining soils. Most extensive along the W. Ghats from Tirunelveli nearly up to Bombay; though often only as residual patches especially towards the north.

Maharashtra

Along the W. Ghats nearly from Bombay and southwards.

Mysore, Madras and Kerala

Along the whole length of the W. Ghats through Mysore (Shimoga, Mangalore, Coorg, Wynaad), Palghat, Tirunelveli.

Andamans

On moist loamy hills throughout the Islands.

4. LOCALITY FACTORS

Temperature.—The mean temperature of the year is very close to 27° C, and the mean January minimum is always over 18° C and usually about 21° C. Data are given for three fairly representative stations in the following statement.

Temperature Data (centigrade)

Southern tropical wet evergreen forests

Month	Kerala MANGALORE 22 m.			Kerala COCHIN 3 m.			Andaman Islands PORT BLAIR 80 m.		
	Mean	Mean max.	Mean min.	Mean	Mean max.	Mean min.	Mean	Mean max.	Mean min.
January . .	26·6	31·7	21·4	26·8	30·5	23·1	25·5	29·0	22·0
February . .	26·8	31·1	22·5	27·4	30·6	24·2	25·6	29·7	21·4
March . .	28·2	32·0	24·3	28·3	31·3	25·6	26·4	30·8	21·9
April . .	29·4	32·9	25·8	28·7	31·4	25·9	27·7	31·7	23·7
May . .	29·3	32·7	26·0	28·3	30·8	25·7	27·2	31·7	23·7
June . .	26·6	29·2	23·8	26·5	29·0	23·9	26·5	29·1	23·9
July . .	26·1	28·7	23·5	25·9	28·1	23·7	26·4	28·8	23·9
August . .	26·2	28·8	23·4	25·9	28·0	23·9	26·2	28·6	23·7
September . .	26·3	29·1	23·5	26·2	28·3	24·1	25·8	28·4	23·2
October . .	26·8	29·9	23·7	26·6	29·1	24·1	26·0	28·8	23·2
November . .	27·1	31·0	23·1	26·9	29·8	24·1	26·0	28·8	23·1
December . .	26·8	31·7	21·4	26·9	30·3	23·4	25·7	28·7	22·7
M. A. T. . .	27·2	..	..	27·1	..	..	26·3	..	..
Annual mean max.	30·7	..	..	29·8	..	..	29·4	..	..
Highest record .	37·8	..	..	33·9	..	..	36·1	..	..
Annual mean min.	23·6	..	..	24·3	..	..	23·1	..	..
Lowest record .	16·7	..	..	17·8	..	..	16·7	..	..
No. of years .	60	..	..	60	..	..	60	..	..

Rainfall and Humidity.—The annual rainfall is from 2000 mm. upwards, rarely down to 1,500 mm. but the type does not spread generally over most sites till 3000 mm. or more is reached. The dry season is not usually prolonged, only 2 to 4 months having less than 50 mm.; if it is longer as in the northern part of the W. Ghats the development of the type requires a heavier rainfall and it is restricted to favourable sites but proximity to the coast also exerts favourable influence. This dry season is connected with the monsoon climate and is more marked than usual in this type in other countries. The monthly rainfall and annual totals for the same stations are given below :

Rainfall (millimetres)

Southern tropical wet evergreen forests

Month	Kerala MANGALORE 22 m.	Kerala COCHIN 3 m.	Andaman Islands PORT BLAIR 80 m.
January	3	23	45
February	2	20	28
March	5	51	28
April	39	125	60
May	157	297	384
June	942	723	562
July	988	592	392
August	597	353	414
September	266	195	442
October	207	340	318
November	72	170	267
December	13	41	201
Total for year (M.A.R.)	3,292	2,929	3,143
No. of rainy days	118	130	150
No. of months with less than 50 mm.	5	3	3
M.A. Humidity	77	79	81
No. of years	60	60	60

Rock and Soil.—The greater part of the tropical wet evergreen forest is found on crystalline rocks, usually gneiss or granite, though it extends over the metamorphic rocks, shales and even limestones and quartzites.

It also extends over alluvial soils in the valleys and notably in the Brahmaputra valley. In the Andaman Islands where excessively free draining sandstones predominate, the type tends to be restricted to outcrops of volcanic rocks, moisture receiving sites in the valleys and low lying alluvial deposits near the coast.

The characteristic features of the soil are its highly leached condition involving low base content, a low silica/sesquioxide ratio, acidic reaction, clay mostly as kaolinite. There is little accumulation of organic matter except locally in wet flats. The mineral nutrient content is largely concentrated in the surface layer where it is maintained by the large amount of organic matter deposited by leaffall etc. from the forest. Nutrient circulation is very rapid and the removal of the forest cover is liable to be quickly followed by a serious and permanent drop in fertility. There is still extremely little known about these soils but a useful summary has recently been published by SETH and YADAV (1960).

Topography.—Flat or hilly ground upto 800 m. extending further up valleys to 1,000 m. or so (with some variation in floristic composition). Very generally the level ground and lower slopes have been cleared in the past, as along the W. Ghats where the type is absent from the coastal plain, but comes in at about 500 m. and extends even upto 1,500 m., the higher slopes getting more rainfall, and more favourable humidity conditions consequent on the lower temperature. Primary climax forest is no longer to be found on the coastal strip, and the soil itself has been degraded by exposure (cf. Type 2A/2S1 on p. 87).

Light.—Practically no information has been collected in India, but in view of the close comparability between Indian tropical evergreen forest and that in other countries, it is probable that similar relationships hold. It appears that the light intensity in the undergrowth is generally about 1% of that prevailing above the top canopy and it is mainly in the red end of the spectrum; during the middle of the day the intensity varies considerably owing to the passage of sunflecks which may briefly raise it to 10—72% of the intensity in the open. For details, see RICHARDS (1952).

5. GENERAL FLORISTICS

Dipterocarps are very characteristic but not an essential constituent; they are more numerous and varied in the S. E. nearer the centre of distribution of the family, and fewer and less varied, and often locally absent on the West Coast; the most widely distributed genera are *Dipterocarpus* and *Hopea*. Other typical components are—*Guttiferae* (notably *Calophyllum*, *Poeciloneuron*, *Mesua*), *Anacardiaceae*. *Sapotaceae*, *Meliaceae*, *Artocarpus*, *Eugenia* and *Elaeocarpus* whilst *Leguminosae* (e.g. *Kingiodendron*) are relatively uncommon (in contrast with similar forests in other countries). These trees are primarily in the top storey.

In the middle canopy which is almost entirely evergreen, the predominant families are *Myrtaceae* and *Lauraceae* but very many others are represented.

Bomboos are relatively rare in the climax type except for such climbing forms as *Dinochloa* and locally *Oxytenanthera nigrociliata* in the Andamans Islands and are often absent. Canes are generally abundant especially on wet ground and there are usually erect palms of several genera.

The shrubby undergrowth when present consists mainly of *Strobilanthes* and other *Acanthaceae* or of evergreen *Rubiaceae* (*Ixora*, *Canthium*, etc.) but many *Anonaceae* and other families are well represented. Other monocotyledons are generally present.

Climbers are on the whole not heavy but may become so in any openings.

6. SUBDIVISIONS, SUCCESSIONS, ETC.

The following four types of which the first is somewhat conjectural are separately described below as also the associated cane and bamboo brakes.

*C*1	(*Giant evergreen forest*)
*C*2	*Andamans tropical evergreen forest*
*E*1	(*Andamans moist deciduous forest*)
*C*3	*Southern hill top tropical evergreen forest*
*C*4	*West Coast tropical evergreen forest*

The finest development of this type of forest, in which giant trees predominate and the evergreen *Dipterocarps* are conspicuous is developed in Southern Burma (EDWARDS, 1950) and Malaya and it is possibly represented in the Andamans under the most favourable conditions of temperature and moisture distribution, and might perhaps be considered to be a post-climax form on deep fresh soils.

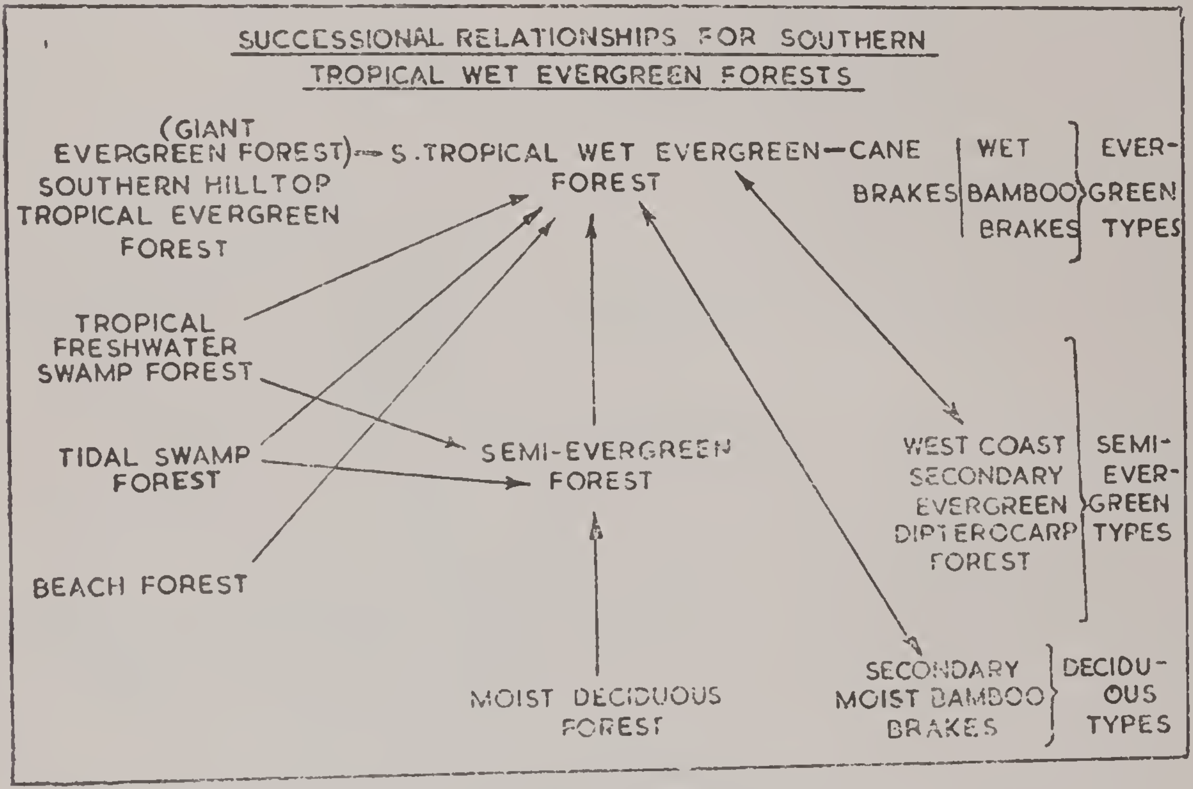
The rather inferior form differentiated as C3 is met with in exposed situations in the face of the monsoon notably in the Andamans where it has some special floristic elements.

Except in the Andamans, the more accessible forests have largely been cleared for permanent or temporary cultivation and some of the present forest is secondary after past clearing. Moreover proximity to settlements has very generally affected the forest in varying degree without amounting to clearing, as also have past unregulated and selective fellings.

Successional relationships are difficult to determine and must often remain conjectural. The larger rivers have deltaic estuaries carrying the various seral forms of tidal forest with more or less beach forest near the sea front and brackish or freshwater swamp behind. In their higher courses, a fringe of *Lagerstroemia* (3/1S2a, p. 154) is usual and there may be fresh-water swamps (4C/FS2, p. 167) where the fall in level is inadequate to drain off the water. These swamp areas may silt up and the level further be raised by silt deposition during inundations and the forest then progresses to an evergreen or semi-evergreen form. Except adjoining deciduous forest or grass land, fire does not spread into the wet evergreen forest. Temporary cultivation particularly in hilly country results in secondary bamboo brake (2/2S1, p. 102) which seems a surprisingly stable type. On flatter ground on the West Coast, a secondary evergreen *Dipterocarp* forest may (2A/2S1, p. 87) result from intensive felling and lopping. In other parts, temporary cultivation results in sub-evergreen forest which is partly residual, partly regrowth from surviving rootstocks and partly new colonisation which would probably progress to the climax form unless it is cleared again when the secondary bamboo is likely to take possession.

A very characteristic predominantly briefly deciduous forest type occurs generally in the Andaman Is. on freely draining slopes, with evergreen or semi-evergreen forest, both above and below, without any discernable climatic difference. This forest must be regarded as a stable edaphic climax occurring under the climatic conditions capable of supporting the more evergreen types on more moisture-retentive sites. It is described with the other Moist deciduous types on p. 103.

The following diagrammatic scheme suggests probable successional relationships.


SUCCESSIONAL RELATIONSHIPS FOR SOUTHERN TROPICAL WET EVERGREEN FORESTS
(GIANT EVERGREEN FOREST)
SOUTHERN HILLTOP TROPICAL EVERGREEN FOREST
S. TROPICAL WET EVERGREEN FOREST
CANE BRAKES
WET BAMBOO BRAKES
EVERGREEN TYPES
TROPICAL FRESHWATER SWAMP FOREST
TIDAL SWAMP FOREST
BEACH FOREST
SEMI-EVERGREEN FOREST
WEST COAST SECONDARY EVERGREEN DIPTEROCARP FOREST
SEMI-EVERGREEN TYPES
MOIST DECIDUOUS FOREST
SECONDARY MOIST BAMBOO BRAKES
DECIDUOUS TYPES

C1. (Giant evergreen forest)

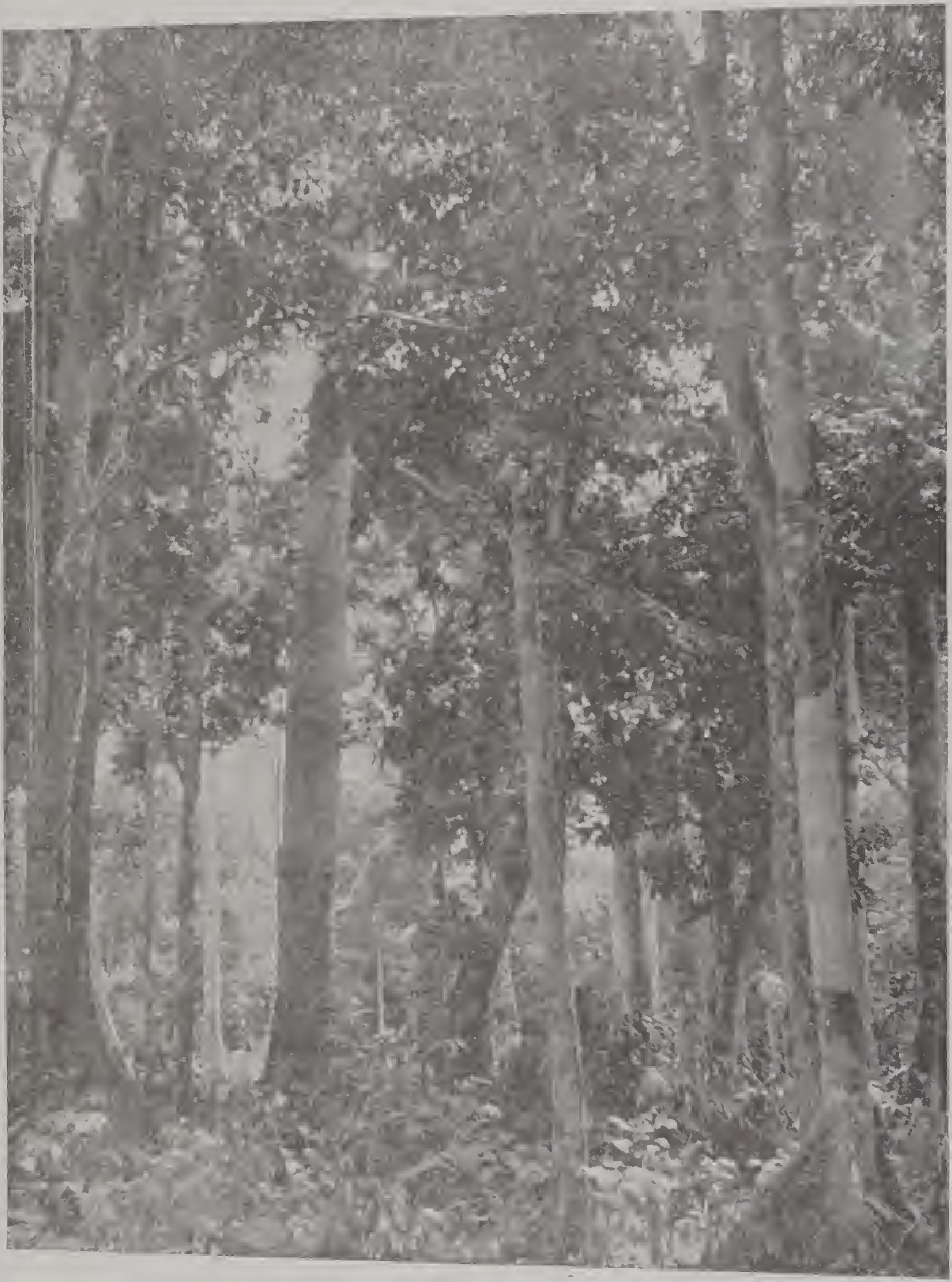
NOMENCLATURE.—*Giant Evergreen.*

DESCRIPTION.—This is the most luxuriant type of forest met with, the climatic climax where site conditions are optimum for tree growth. The top canopy formed by the giant trees is almost entirely evergreen and though usually irregular may locally be more or less complete.

DISTRIBUTION.—Typical of S. E. Asia and may be represented locally in the Andamans and the Western Ghats.

LOCALITY FACTORS.—A rainfall of over 3,000 mm. well distributed, seems to be required and a sufficiently retentive soil if the ground is sloping.

ILLUSTRATION.—cf. Plate 1.



ANDAMANS TROPICAL EVERGREEN FOREST

Dipterocarpus alatus Preservation Plot, Interview Island, North Andamans.

S. K. Seth

ANDAMANS TROPICAL EVERGREEN FOREST

FLORISTICS.—In the Andamans it is met with on deep alluvial soils near the banks of larger streams but is so intimately mixed with the semi-evergreen forest that delimitation is difficult. The semi-evergreen type is described on p. 85 (Type 2A/C1). Adequate floristic lists are wanting but evergreen consociations include *Dipterocarpus alatus*, the loftiest tree in the Andamans and other species such as *D. gracilis*, *Calophyllum soulattri* and *Artocarpus* spp.

C2. Andamans tropical evergreen forest

DESCRIPTION.—As given on p. 57 for the sub-group. Not so luxuriant as the giant Evergreen (Dipterocarp) forest particularly in the height, density and size of the giant top storey, which is very irregular and incomplete, but otherwise very similar in composition. There are fewer species in the top canopy, deciduous species being rather more frequent, and gregarious occurrence commoner.

DISTRIBUTION.—Throughout the Andamans typically as caps to the hills with moist deciduous forests on the slopes. Similar forest occurs in the Nicobar Islands.

LOCALITY FACTORS.—As for the sub-group p. 58.

ILLUSTRATIONS.—Plates 1, 2.

FLORISTICS.—

(i) *Andamans.* (CHENGAPPA).—

I. *Dipterocarpus grandiflorus**, *D. pilosus*, *Artocarpus chaplasha*, *A. gomeziana*, *Calophyllum soulattri**, *Planchonia andamanica*, *Hopea odorata*, *Endospermum chinense*, *Sideroxylon longepetiolatum*.

II. *Xanthochymus andamanicum*, *Myristica andamanica*, *M. glaucescens*, *Baccaurea sapida*, *Croton argyratus*, *Pterospermum aceroides*, *Caryota mitis*, *Cryptocarya*, *Memecylon*, *Euphorbia epiphylloides*, *Pseuduvaria prainii*, *Actephila excelsa*.

III. *Anaxagorea luzoniensis*, etc.

V. *Dinochloa andamanica*, *Calamus palustris*, *Gnetum scandens*, *Ancistrocladus extensus*.

(ii) *Gopalkabang valley, South Andamans.*—

I. *Dipterocarpus kerrii**, *D. grandiflorus*, *D. gracilis*.

II. *Artocarpus*, *Planchonia*, *Hopea odorata*, *Pterospermum aceroides*, *Myristica andamanica*, *Elaeocarpus* sp.

IIa. *Oxytenanthera nigrociliata*.

III. *Macaranga andamanica*, *Mussaenda macrophylla*, *Leea* sp., *Evodia glabra*, *Licuala peltata*, *Pandanus*, *Clinogyne grandis*.

IVb. *Erianthus arundinaceus*.

V. *Dinochloa andamanica*, *Ancistrocladus*, *Calamus palustris*, *C. longisetosus*, *C. pseudorivalis*, *Gnetum scandens*.

NOTE.—*Dipterocarpus* forms a more or less pure stand in the top storey but is present in all layers.

(iii) *Great Nicobar Island* (SAHNI).—

I. *Calophyllum soulattri**, *Sideroxylon longepetiolatum, Garcinia xanthochymus, Adananthera payonina, Albizzia lebbek, Pisonia umbellifera, Mangifera sylvatica.*

II. *Myristica* spp., *Polyalthia* spp.

NOTE.—This type covers the hills, the valleys forests have a different composition and include *Musa* spp., and tree ferns, as well as the extensive climbing bamboo *Dinochloa*. *Dipterocarpus* is absent.

GENERAL NOTE.—*Dipterocarpus grandiflorus* is a conspicuous member of evergreen forests occurring on moist clayey hill slopes which are best viewed as examples of Type 1A/C2, p. 63. Similarly the *Dipterocarpus kerrii* association which is dominated by this species but only attains a moderate height occurs in a few restricted localities in S. Andamans.

C2/E1. (Andamans moist deciduous forest)

This is described on p. 103.

C3. Southern hill top tropical evergreen forest

DESCRIPTION.—A more or less inferior edition of the typical wet evergreen, not more than 10 m. high in extreme cases.

DISTRIBUTION.–Andamans and W. Ghats, on the upper slopes and tops of hills and sometimes on steep slopes lower down.

LOCALITY FACTORS.—Exposure to wind and generally less favourable conditions of soil and climate than the main climax form. Rainfall is usually high, over 4,500 mm., and humidity is high during the period of low rainfall.

FLORISTICS.—

(i) *Andamans.* (PARKINSON and CHENGAPPA)—

I. *Dipterocarpus costatus**, *Mesua ferrea, Canarium manii, Harpullia cupanioides, Hopea andamanica, Cratoxylon formosum, Euphorbia trigona* and *E. epiphylloides.*

II. *Memecylon caeruleum, Cryptocarya ferrarsi* and some small bamboos. *Phoenix* sp., (local).

NOTE.—Apparently a true edaphoclimatic climax in the areas mentioned, sometimes forming a transition to the subtropical montane type.

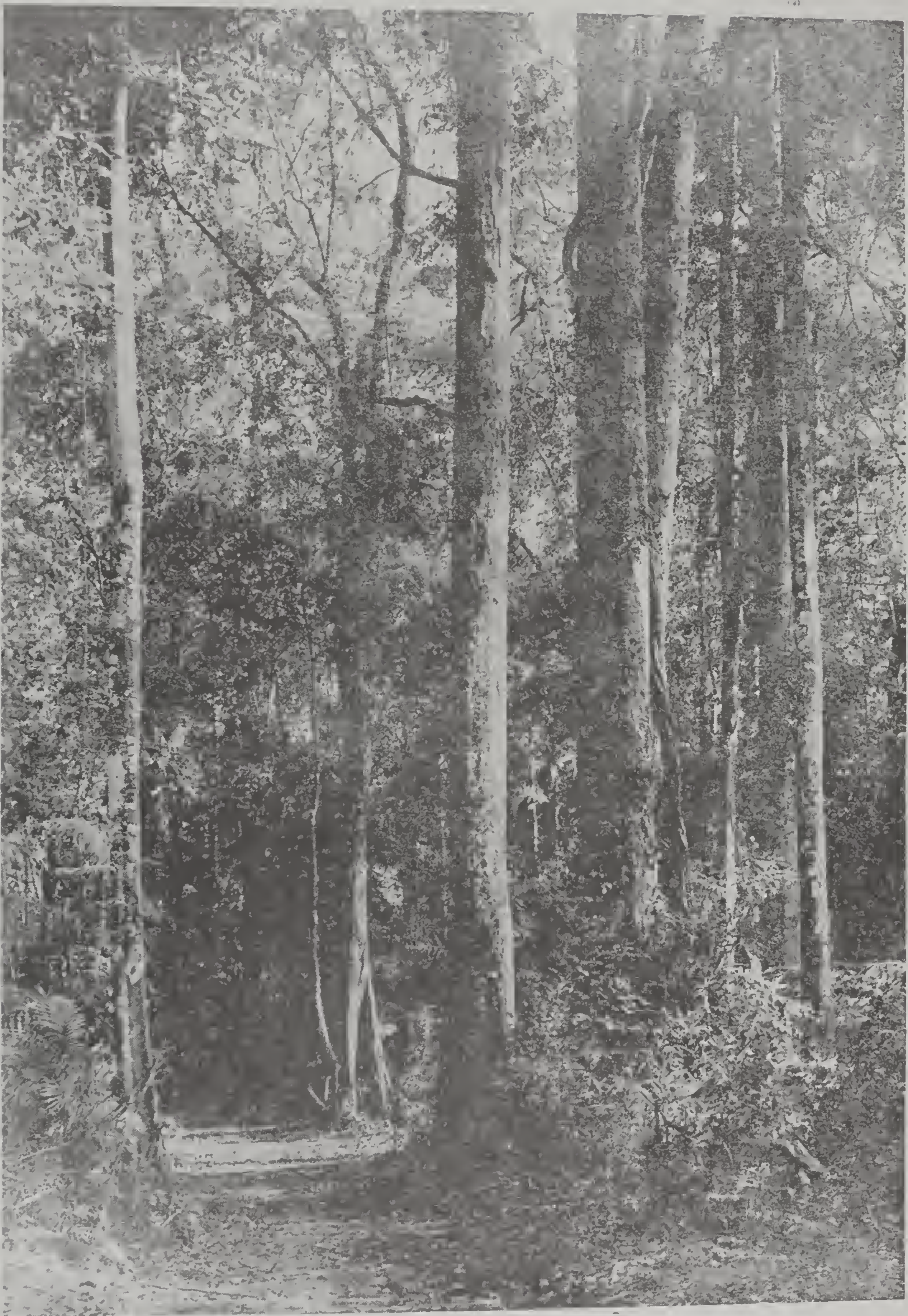
(ii) *Ranni, Kerala* (Cir. 1000 m.) (PILLAI)—

I. & II. *Mesua ferrea**, *Dysoxylum malabaricum, Cullenia excelsa, Holigarna beddomei, Calophyllum elatum, Cedrela toona, Canarium strictum, Artocarpus heterophyllus, Palaquium ellipticum, Hopea parviflora, Eugenia* spp., *Elaeocarpus* sp.

IIa. *Ochlandra travancorica.*

III. *Pandanus, Strobilanthes.*

V. *Calamus* spp.



WEST COAST TROPICAL EVERGREEN FOREST

Dipterocarpus bourdilloni (various sizes), *Kingiodendron pinnatum* (large tree), *Polyalthia* sp., *Vitex altissima* with evergreen undergrowth and canes.
Shendurney, Shencottah Division, Kerala.

M. V. Laurie

(iii) *Muthukuzhi, Tirunelveli South Division, Madras* (1200-1500 m.)—

I. *Hopea parviflora*, Calophyllum elatum*, Dysoxylum malabaricum, Cullenia excelsa, Artocarpus hirsuta, Lophopetalum wightianum, Tetrameles nudiflora.*

II. *Syzygium cumini, Cinnamomum zeylanicum, Elaeocarpus serratus, Macaranga roxburghiana.*

III. Dense evergreen shrubs and reeds.

V. Canes *Entada phaseoloides, Calycopteris floribunda, Dioscorea* sp.

C4. West Coast tropical evergreen forest

DESCRIPTION.—As given for the sub-group on p. 60 except that the genus *Dipterocarpus* is infrequent or absent and that there are other characteristic floristic differences as revealed by the lists given.

With increasing elevation and high rainfall the height of the forest diminishes—though it remains dense and evergreen—changing into the relatively stunted montane wet sub-tropical forest (page 254). There is no sharp line of change although a plateau configuration may reduce the extent of transition stages.

DISTRIBUTION.—All along the western ghats from about Ratnagiri district southwards wherever humidity and soil moisture conditions are favourable.

LOCALITY FACTORS.—Rainfall 1500-5000 mm. or more; altitude 250 to 1200 m. Mangalore and Cochin may be taken as fairly typical though neither is in the forest belt.

ILLUSTRATIONS.—Plates 3, 4, 5.

FLORISTICS.—HIGH LEVEL TYPE.

(i) *Kanara Eastern, Mysore*—

I. *Dipterocarpus indicus*, Calophyllum elatum, C. wightianum, Hopea wightiana, Holigarna arnottiana, H. grahamii, Olea dioica, Lophopetalum wightianum, Polyalthia coffeoides, Machilus macrantha, Mangifera indica, Chrysophyllum roxburghii.*

II. *Aglaia roxburghiana, Euphoria longana, Aporosa lindleyana, Lansium anamalayanum, Nothopegia colebrookiana, Litsea* spp., *Ponteria tomentosa, Flacourtia montana; Caryota urens, Areca.*

III. *Strobilanthes* spp., *Psychotria* spp., *Leea.*

V. Canes.

NOTE.—*Dipterocarpus indicus* and *Calophyllum elatum* together account for about 5% of the crop. *D. indicus* towers over others.

(ii) *Agumbe, Mysore* (Ghat crests 300-800 m.)—

I. *Dipterocarpus indicus** (a), *Poeciloneuron indicum* (a), *Mesua ferrea* (a), *Hopea parviflora* (o), *Dysoxylum malabaricum, Calophyllum elatum, Machilus macrantha, Palaquium ellipticum* and many others.

II. *Myristica* sp., *Euphoria longana, Lansium anamalayanum, Unona pannosa, Humboldtia brunonis, Aglaia odoratissima, Hopea wightiana* etc.

IIa. *Oxytenanthera* spp.

III. *Rubiaceae, Strobilanthes, Pinanga dichsoni, Arenga wightii, Pandanus.*

V. *Calamus* spp.

(iii) *Makut (Coorg), Mysore*—

I. *Vateria indica**(a), *Kingiodendron pinnatum* (a), *Dipterocarpus indicus* (a), *Cedrela* sp. (o), *Mesua ferrea* (o), *Holigarna arnottiana* (o), *Mangifera* sp. (o) *Artocarpus hirsuta* (o), *Dysoxylum malabaricum* (o), *Hopea parviflora* (f), *Calophyllum elatum* (f).

II. *Elaeocarpus* spp. (a), *Myristica* spp. (a), *Hemicyclia elata* (a), *Dichopsis elliptica* (f), *Schleichera oleosa, Canarium strictum.*

(iv) *High Level Evergreen Forests of Wynaad, Kerala*—

These forests are characterised by a high proportion of *Mesua ferrea, Palaquium ellipticum, Cullenia excelsa* and *Calophyllum elatum*. The absence of *Dipterocarpus indicus, Filicium, Kingiodendron pinnatum* and *Hopea* is noteworthy; these species are met with at lower elevations in the adjoining Kannoth block, where *Mesua* is absent.

I. *Palaquium ellipticum** (a), *Vateria** (a), (especially near water courses), *Calophyllum elatum* (o), *Cullenia excelsa* (o), *Dysoxylum malabaricum* (lo), *Artocarpus hirsuta* (r), *Cedrela toona* (o), *Machilus macrantha* (o), *Mesua ferrea* (f), *Elaeocarpus tuberculatus* (f), *Bischofia* (f), *Eugenia* spp. (f), *Canarium* (f).

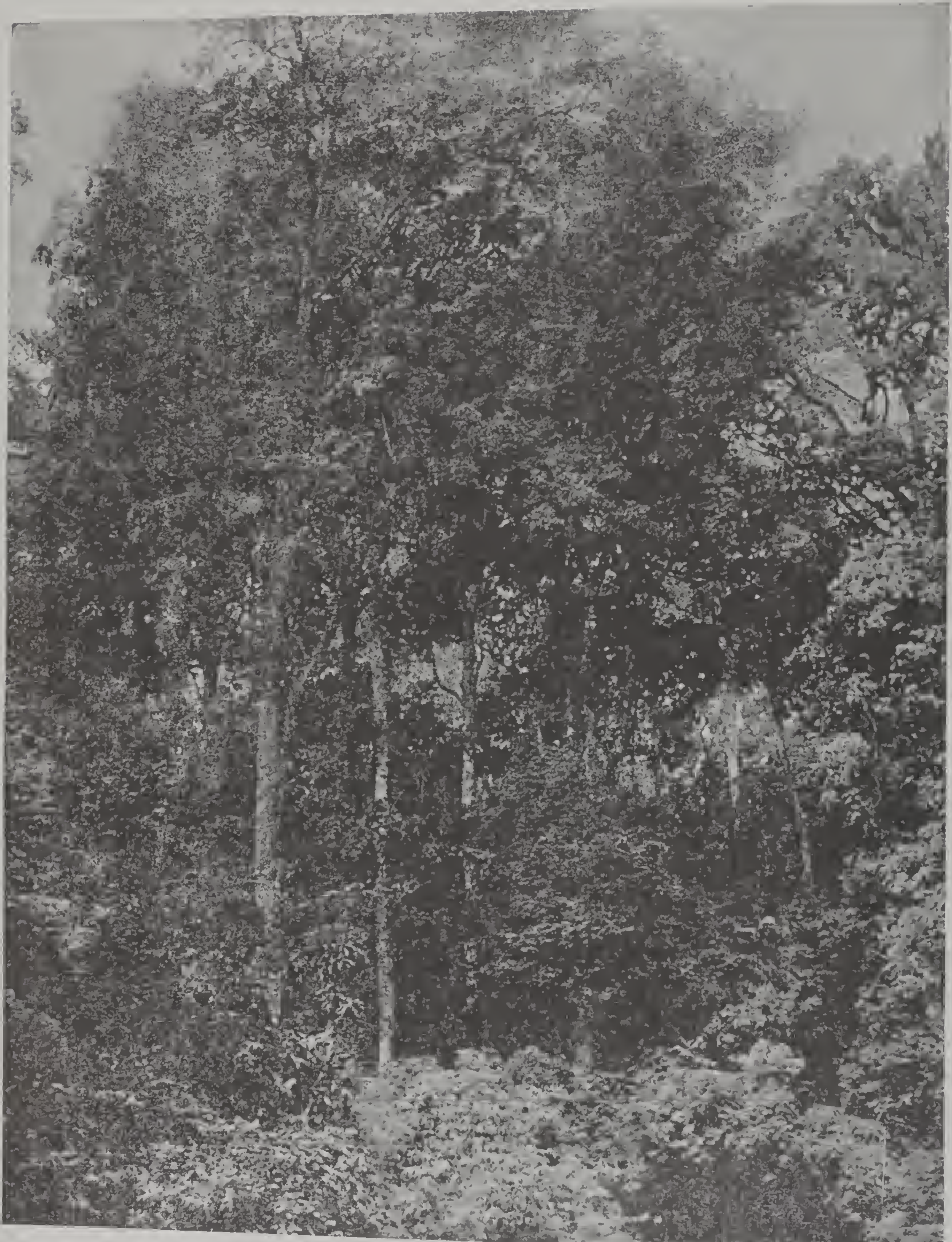
II. *Palaquium ellipticum* (a), *Myristica* spp. (o), *Vateria* (f), *Eugenia munroi* (f), *Actinodaphne hirsuta* (f), *Ostodes* (f), *Euphoria longana* (f), *Litsea* sp (f), *Meliosma simplicifolia* (lf), *Polyalthia coffeoides* (f), *Cinnamomum zeylanicum* (f), *Elaeocarpus serratus* (f), etc.

IIa. Bamboos appear mainly as *Ochlandra* brakes along the larger streams but occasionally spread out on the slopes.

III. *Leea indica* (a), *Rubiaceae* (a), *Apama* (a), *Areca* (la), *Strobilanthes* spp. (la), *Psychotria, Lasianthus, Pandanus* sp. (la), *Glycosmis* (lf), *Calamus* sp. (lf), *Laportea crenulata* (f), Large ferns (f).

IVb. No grass in undisturbed forest.

V. Climbers on the whole, are not heavy though locally they may be so.



WEST COAST TROPICAL EVERGREEN FOREST

Dipterocarpus indicus association with Euphoria longana, Hopea wightiana etc.

L. I. P. No. 2, Kanara East Division Mysore.

M. A. Waheed Khan

(v) *Karian Shola, Anamalais, Madras.* (LAURIE)—

I. *Hopea parviflora** (a), *Mesua ferrea** (a), *Vitex altissima* (a), *Aglaia roxburghiana* (a), *Elaeodendron glaucum* (a), *Polyalthia fragrans* (a), *Diospyros microphylla* (a), *Eugenia gardneri* (a), *Canarium strictum* (o), *Artocarpus lakoocha* (o), *Bischofia javanica* (o), *Artocarpus heterophyllus* (o), *Trewia nudiflora* (o), *Alstonia scholaris* (o), *Dysoxylum malabaricum* (o), *Machilus macrantha* (o), *Filicium decipiens* (o), *Tetrameles nudiflora* (o), *Carallia lucida* (o), *Mangifera indica* (o), *Beilschmiedia bourdilloni* (o), *Pygeum wightianum* (o), *Calophyllum elatum* (f), *Salmalia malabarica* (f), *Spondias pinnata* (f), *Litsea* sp. (f).

II. *Cyclostemon macrophyllus* (a), *Gomphandra polymorpha* (a), *Dimorphocalyx lawianu* (a), *Euphoria longana* (a), *Scolopia crenata* (a), *Excaecaria robusta* (a), *Diospyros bourdilloni* (a), *Acronychia pedunculata* (a), *Adenochlaena indica* (a), *Garcinia* sp. (a), *Canthium dicoccum* (c), *Mallotus philippensis* (o), *Flacourtia indica* (o), *Sapindus laurifolius* (o), *Harpullia arborea* (o), *Fagara budrunga* (o), *Hydnocarpus wightiana* (o), *Actinodaphne hirsuta* (o), *Cinnamomum wightianum* (f), *Pterospermum heyneanum* (f), *Mimusops elengi* (f), *Amoora canarana* (f), *Holigarna grahamii* (f), *Prosporus indicus* (f), *Ostodes zeylanica* (f), *Myristica laurifolia* (f), *Casearia esculenta* (f).

III. *Strobilanthes* spp. (a), *Orophea zeylanica* (o), *Nothopegia* sp. (o), *Ixora arborea* (o).

IV. *Entada phaseoloides* (o), *Calamus* spp. (f).

(vi) *High Level Evergreen Forests of Palghat* (*Kerala*)—

I. *Cullenia excelsa**, *Machilus macrantha*, *Elaeocarpus tuberculatus*, *E. munroii*, *Palaquium ellipticum*, *Mesua ferrea**, *Calophyllum elatum*, *Canarium strictum*, *Dysoxylum malabaricum*, *Vateria indica*, *Poeciloneuron indicum**, *Eugenia* sp., *Heritiera papilio*, *Donella roxburghii*, *Mangifera indica*, *Artocarpus heterophyllus*, *Polyalthia coffeoides*, *Cinnamomum zeylanicum*, *Holigarna arnottiana*, *H. grahamii*, *Meliosma microcarpa*, *Hopea glabra*, *Litsea wightiana*, *Mastixia arborea*, *Dryptes elata*, *Cyclostemon confertiflorus*, etc.

II. *Myristica laurifolia*, *Hydnocarpus laurifolia*, *H. alpina*, *Euphoria longana*, *Lasium anamalayanum*, *Garcinia spicata*, *Elaeocarpus serratus*, *Symphyllia mallotiformis*, *Gomphandra polymorpha*, *Gordonia obtusa*, *Syzygium* sp., *Baccaurea courtallensis*- *Glochidion malabaricum*, *Canthium dicoccum*, *Scolopia crenata*, *Xanthophyllum flavescens*, *Nothapodytes foetida*, *Actinodaphne hookeri*.

IIa. *Ochlandra beddomei*.

III. *Euonymus angulatus*, *Agrostachys indica*, *A. longifolia*, *Eugenia munroii*, *Syzygium lineatum*, *Paramignya beddomeii*, *Sauropus albicans*, *Leea indica*, *Saprosma fragrans*, *Webera* sp., *Clerodendron viscosum*, *Macaranga peltata*, *Strobilanthes* sp., *Laportea crenulata*, *Olea dioica*, *Linocera malabarica*, *Callicarpa lanata*, *Pavetta* *zeylanica, Verooia arborea, Turpenia malabarica, Orphea uniflora, Sarcococca brevifolia, Croton scabiosus.* Monocotyledonous forms include—*Arenga wightii, Pinanga dicksonii, Calamus* spp., *Pandanus furcatus.*

IVa. Herbaceous ground flora—*Elettaria cardamomum*, wild arrow root, *Curcuma* sp. *Heckeria subpeltata.*

V. Climbers—*Gnetum scandens, Calamus* sp., *Smilax zeylanica, Elaeagnus latifolia, Derris* sp., *Entada phaseoloides, Senecio araneosus, Thunbergia mysorensis, Paramignya* sp., *Luvunga eleutherandra, Morinda* spp.

NOTE.—This form is found in the Silent and Attapadi valleys. *Palaquium ellipticum*, is by far the most abundant species. Common also are *Mesua ferrea, Poeciloneuron indicum, Cullenia excelsa, Machilus macrantha, Calophyllum elatum*, etc. Considerable occurrence of *Poeciloneuron indicum* is specially noticeable and the absence of *Dipterocarpus* species is also noteworthy.

(vii) *High Level Evergreen Forests of Nilambur (Kerala)*—

I. *Palaquium ellipticum*, Cullenia excelsa, Calophyllum elatum, Terminalia bellerica, Machilus macrantha, Dysoxylum malabaricum, Elaeocarpus tuberculatus, Artocarpus hirsuta.*

II. *Eugenia gardneri, Cinnamomum zeylanicum, Bischofia javanica*, Cedrela toona, Elaeocarpus* sp., *Xylopia parviflora.*

IIa. *Ochlandra* spp. are met with as gregarious patches.

III. *Strobilanthes, Rubiaceae, Pinanga dicksonii, Arenga wightii.*

V. Climbers—*Entada phaseoloides*, wild pepper, *Smilax*, etc.; occasional *Calamus.*

NOTE.—Here *Palaquium* is the commonest species. *Hopea* is found sparsely, scattered below 750 m. *Mesua ferrea* is abundant from 900 m. to 1,200 m. *Calophyllum* tends to be gregarious in patches. *Dipterocarpus* is absent.

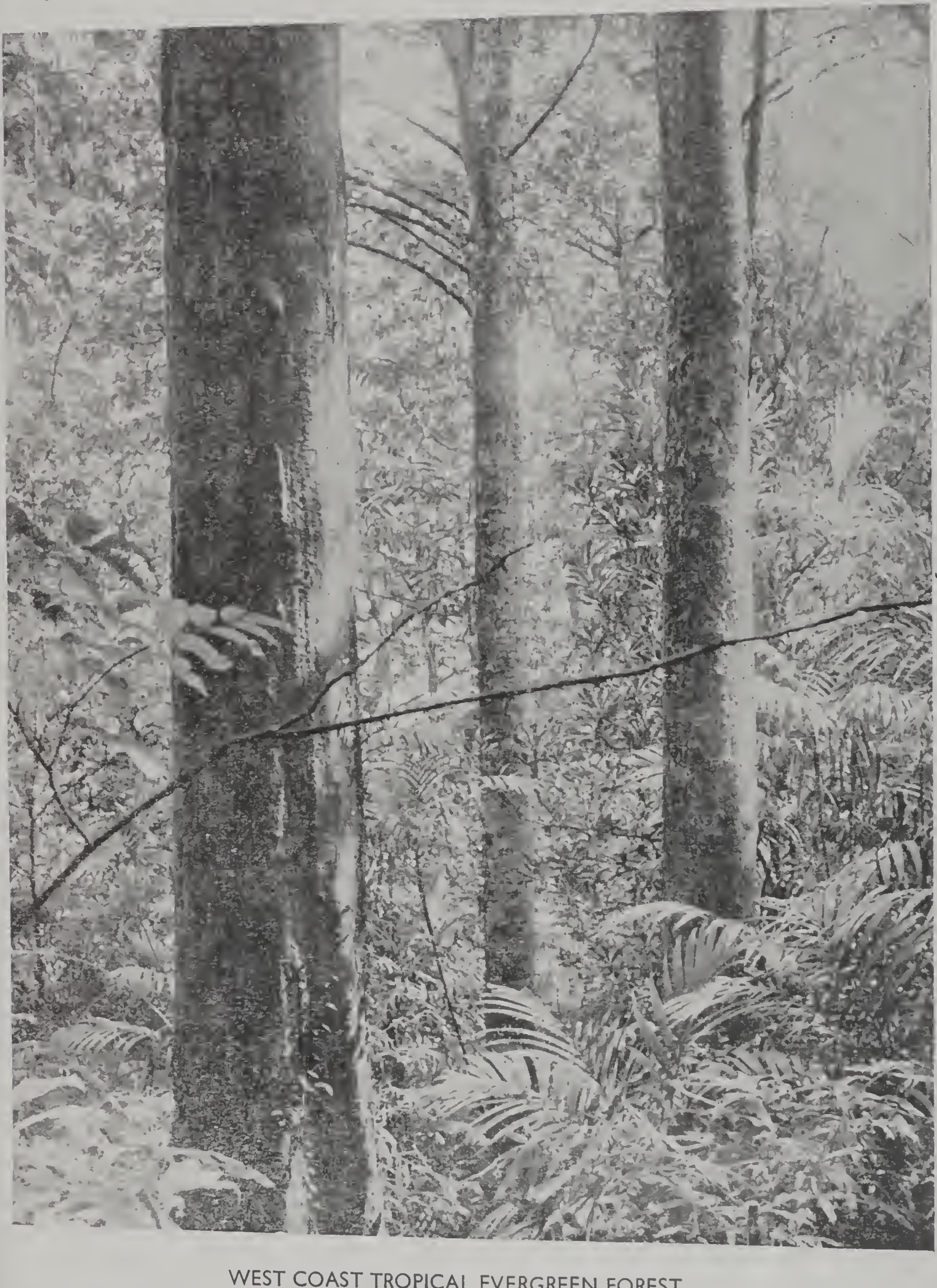
LOW LEVEL TYPE

(i) *Wynaad, Kerala*—

I. *Vateria indica** (a), *Artocarpus hirsuta* (f), *Dysoxylum malabaricum* (f), *Acrocarpus fraxinifolius* (o), *Hopea parviflora** (a), *Dipterocarpus indicus* (f), *Filicium decipiens* (f), *Kingiodendron pinnatum* (f), *Elaeocarpus* sp. (f), *Bischofia javanica* (o), *Cedrela toona* (f), *Eugenia* sp. (f).

II. *Myristica* sp. (o), *Litsea* sp. (f), *Hydnocarpus laurifolia** (a), *Pterygota alata* (o), *Vitex altissima* (o), *Schleichera oleosa* (f), *Cinnamomum* sp. (o), *Pterospermum rubiginosum* (f).

III. *Leea indica* (a), *Strobilanthes* (f), *Calamus* sp. (lf), ferns (la), *Rubiaceae* (a), *Arenga wightii* (la)



WEST COAST TROPICAL EVERGREEN FOREST

A group of *Dipterocarpus indicus* on moist soil with palm undergrowth.

L. I. P. No. 2, Kanara East Division, Mysore.

S. K. Seth

IVb. Grasses—do not occur.

V. Climbers—not heavy.

(ii) *Kanara Eastern, Mysore* (Devimane 300 m.)

I. *Hopea wightiana**, *Diospyros candoleana, Olea dioica, Syzygium cumini, Holigarna arnottiana, Pterospermum heyneanum, Memecylon edule, Cinnamomum* spp., *Syzygium gardneri, Artocarpus heterophyllus, A. hirsuta, Lophopetalum wightianum, Calophyllum elatum, Machilus macrantha, Mangifera indica, Mimusops elengi, Terminalia paniculata, Lagerstroemia lanceolata.*

II. *Aglaia roxburghiana, Garcinia* sp., *Symplocos canarana, Canthium dicoccum, Euphoria longana, Aporosa lindleyana, Saraca indica, Litsea* spp., *Flacourtia montana, Pouteria tomentosa, Madhuca longifolia, Hydnocarpus laurifolia.*

IIa. Bamboos are practically absent.

III. *Strobilanthes* spp., *Psychotria dalzelli, Leea sambusina, Goniothalamus cordiopetalus, Litsea* spp.

V. Canes common, sometimes abundant.

NOTE.—Regeneration of the main species is frequent.

GENERAL NOTE.—There are some differences between the low level forms met with from 250 to 500 m. illustrated by examples and the high level forms, which are typical and best developed examples of west coast evergreen forests, described above. In the low level form *Cullenia excelsa* and *Poeciloneuron* are absent and *Mesua ferrea, Palaquium ellipticum* and *Calophyllum elatum* are less frequent. There is a high proportion of *Hopea parviflora, Kingiodendron pinnatum, Artocarpus hirsuta, Acrocarpus fraxinifolius, Vateria indica* etc. *Hopea* tends to be gregarious and is quite abundant. *Vateria* is also abundant. Floristic lists are given by CHANDRASEKHARAN.

Many associations have been distinguished by AHUJA, AIYAR, ARORA, CHANDRASEKHARAN, KADAMBI, WILSON, and others. Their constitution and status depends upon altitude, rainfall, soil, exposure to wind, availability of species etc. and varies from place to place. However, the top canopy associations are dominated by relatively few species especially *Hopea, Cullenia, Palaquium, Poeciloneuron, Calophyllum, Dipterocarpus, Vateria* and *Mesua*. Among additional species characteristic of edaphic variants on the above, may be mentioned *Elaeocarpus, Lophopetalum, Hopea wightiana* and *Ochlandra*.

The principal characteristic of a selection of the associations in the southern west coast region are summarised in the following table.

Some typical associations of West Coast Tropical Evergreen Forests

Association	Typical altitude	Typical soil	Typical rainfall	Typical status	Typical occurrence
1. *Filicium—Alseodaphne* .	250—600 m.	shallow, lateritic	2500 mm.	edaphic climax	TIRUNELVELI—Madras
2. *Hopea—Mesua* . .	300—500 m.	moderately moist	3000 mm.	low elevation climax	SOUTH COIMBATORE; KANYAKUMARI—Madras
3. *Poeciloneuron—Mesua* .	320—800 m.	moist	cir. 5000 mm.	climax	AGUMBE—Mysore
4. *Hopea (wightiana)—Palaquium*	320—800 m.	drier	cir. 5000 mm.	table land climax	HASSAN—Mysore
(4a) *Elaeocarpus tuberculatus*	..	moister	..	edaphic variant of *Vateria*. (6c)	AGUMBE—Mysore
5. *Poeciloneuron—Dipterocarpus*	320—800 m.	moist	cir. 5000 mm.	moist climax	AGUMBE—Mysore
6. *Palaquium—Dipterocarpus*	cir. 650 m.	moist, well drained	cir. 5000 mm.	climax	HASSAN—Mysore THENMALA—Kerala.
(6a) *Hopea wightiana* .	cir. 650 m.	drier, lateritic	..	transitional, edaphic climax on steep slopes.	AGUMBE; HASSAN—Mysore
(6b) *Lophopetalum wightianum* .	cir. 650 m.	wet, marshy	..	edaphic climax, variant of *Vateria*.	AGUMBE; HASSAN—Mysore
(6c) *Vateria indica* .	cir. 650 m.	wet stream banks	..	edaphic climax, variant of *Elaeocarpus* (4a) or *Lophopetalum* (6b)	HASSAN—Mysore
7. *Dipterocarpus—Hopea* .	cir. 650 m.	moist, deep, clayey loam.	cir. 5000 mm.	low elevation climax	KANARA EAST—Mysore
8. *Palaquium—Mangifera* .	650—800 m.	clayey, slowly drained.	4000 mm.	medium elevation climax.	TIRUNELVELI; KANYAKUMARI-Madras

(8a) *Gluta—Palaquium* .	..	moister	..	edaphic climax	TIRUNELVELI—Madras.
9. *Cullenia—Palaquium*	800—1100 m.	deep, well drained	5000 mm.	medium elevation climax	PALGHAT—Kerala TIRUNELVELI—Madras
(9a) *Ochlandra—Calophyllum*	..	wet	4000—5000 mm.	edaphic post climax	PALGHAT—Kerala
(9b) *Vateria—Cullenia* .	..	moister, well drained	..	edaphic climax	PALGHAT—Kerala
(9c) *Cullenia—Palaquium—Mesua*	..	drier	..	altitudinal variant	PALGHAT—Kerala
10. *Dipterocarpus—Vateria* .	cir. 1000 m.	well drained	6000 mm.	optimum moisture climax.	BISALE—Mysore
(10a) *Vateria—Elaeocarpus*	..	wet	..	edaphic climax, along streams.	BISALE—Mysore
11. *Palaquium—Mesua* .	1000—1200 m.	moist	4000 mm.	medium elevation climax.	AGUMBE—Mysore SOUTH COIMBATORE; TIRUNELVELI—Madras PALGHAT—Kerala
12. *Cullenia—Calophyllum* .	over 1100 m.	wet	3000 mm.	edaphic post climax	KANYAKUMARI—Madras
13. *Poeciloneuron—Palaquium*.	1000—1200 m.	damp or wet	5000 mm.	optimum moisture climax.	AGUMBE; KADUR—Mysore.
14. *Poeciloneuron—Cullenia* .	1000—1200 m. (Ghat crests)	damp	5000 mm.	optimum moisture climax.	SOUTH COIMBATORE—Madras
(14a) *Elaeocarpus tuberculatus*	..	moist	..	edaphic variant	AGUMBE—Mysore
(14b) *Vateria—Mesua* .	over 1200 m.	damp or wet	..	edaphic climax	PALGHAT—Kerala
(14c) *Ochlandra—Poeciloneuron*	..	marshy	..	edaphic post climax	PALGHAT—Kerala
(14d) *Poeciloneuron*	..	damp or wet	..	edaphic climax, near streams.	KADUR—Mysore
15. *Mesua—Calophyllum* .	1100—1300 m.	moister	5000 mm.	high elevation climax.	PALGHAT—Kerala

Sub-group 1B. Northern Tropical Wet Evergreen Forests

1. NOMENCLATURE

General	Tropical evergreen rain forest (in part) (SCHWEINFURTH).
Bengal	Wet evergreen forest.
Assam	Evergreen forest. Evergreen Dipterocarp forest.

2. GENERAL DESCRIPTION

The type is virtually identical in form with the southern evergreen described on p. 57 and more particularly with the type for which the term West coast tropical evergreen has been adopted. Large tall evergreen trees form the bulk of the main canopy which is perhaps rather less continuous and even but is still completed by the somewhat smaller trees. Single giant Dipterocarps and similar trees or groups of them may project above the general level. The number of species is very great, and the mixture very intimate, only a few species forming small consociations. Deciduous trees are few. The middle and lower canopies are particularly dense, evergreen and varied. Bamboos are perhaps rather more frequently seen than in the southern counterpart but their presence possibly similarly indicates a non-climax condition. Small palms are common but less varied and conspicuous than in the south. Canes and other climbers are abundant and epiphytes of all sorts very numerous. There is typically a ground cover of evergreen shrubs, herbaceous vegetation being scarce and grasses absent.

3. DISTRIBUTION

The type occurs throughout N.E. India from Bengal eastwards and southwards wherever the annual rainfall exceeds 2,500 mm. and the soil is reasonably retentive of moisture. It also occurs with a rather smaller rainfall if it is well distributed. A great deal of the area for which the type is the climatic climax has been cleared or so greatly altered by biotic influences that it is now under sub-climax forest or cultivation; this is particularly so in Bengal and E. Assam.

West Bengal	In all submontane divisions; the type is extending in reserve forest with general protection.
Assam	The whole except the tract of low rainfall centering on Nowgong, though much is low secondary growth in various stages of secondary progression.
Orissa	Possibly the original type in the damper parts of the coastal strip.

4. LOCALITY FACTORS

Temperature.—The mean annual temperature lies between 22° C and 26° C which is only a few degrees below that of the southern form (25° C—27° C), but the mean annual minimum temperature is very much lower, being under 10° C as compared with a typical figure of 16° C for the southern form. The January minimum is also about 10° C-16° C as compared with over 18° C. The stations for which the data are given in the following table lie outside the forests and probably do not fully reflect its moderating influence.

Temperature (centigrade)

Northern tropical wet evergreen forests

Month	Assam SIBSAGAR 97 m.			Assam DIBRUGARH 106 m.			Assam SRIMANGAL 21 m.			Assam SILCHAR 29 m.		
	Mean	Mean max.	Mean min.	Mean	Mean max.	Mean min.	Mean	Mean max.	Mean min.	Mean	Mean max.	Mean min.
January . .	15·6	21·4	9·8	16·0	21·9	10·1	17·5	26·4	8·6	18·4	25·6	11·3
February .	17·4	22·8	12·0	17·7	22·8	12·6	19·6	28·2	11·1	20·1	27·0	13·2
March . .	20·9	26·2	15·6	21·1	26·1	16·0	24·4	32·3	16·4	23·8	30·3	17·2
April . .	23·2	27·6	18·9	23·0	27·2	18·8	27·1	33·4	20·7	28·6	31·1	26·0
May . .	25·8	29·6	22·1	25·3	29·2	21·5	27·6	32·8	22·3	27·1	31·5	22·6
June . .	28·0	31·4	24·5	27·0	30·6	23·4	28·2	32·2	24·2	28·2	31·8	24·6
July . .	28·6	31·8	25·4	27·4	30·7	24·1	28·6	32·4	24·7	28·7	32·3	25·1
August . .	28·4	31·4	25·3	27·6	30·7	24·4	28·4	32·3	24·5	28·4	31·9	24·9
September .	27·7	30·9	24·6	26·9	30·2	23·6	28·2	32·4	24·1	28·3	32·1	24·6
October . .	25·2	28·9	21·4	24·9	29·1	20·8	26·4	31·7	21·2	26·8	31·3	22·9
November .	20·6	25·6	15·4	21·0	26·4	15·6	19·8	29·7	15·3	23·4	29·4	17·5
December .	16·4	22·3	10·5	17·0	23·3	10·6	18·3	26·9	9·6	19·6	26·6	12·6
M. A. T. .	23·4	..	..	22·9	..	..	24·7	..	..	25·1	..	..
Annual mean maximum .	27·7	..	..	27·3	..	..	30·9	..	..	30·1	..	..
Highest record.	38·9	..	..	38·9	..	..	41·1	..	..	39·4	..	..
Annual mean minimum .	19·0	..	..	18·4	..	..	18·6	..	..	20·2	..	..
Lowest record .	2·8	..	..	4·4	..	..	1·7	..	..	5·0	..	..
No. of years .	70	..	..	40	..	..	45	..	..	60	..	..

Rainfall and Humidity.—Rainfall data are as follows:—

Rainfall (millimitres)

Northern tropical wet evergreen forests

Month	Bengal SAM SINGH T.E.	Bengal FAGU T.E.	Assam SIBSAGAR 97 m.	Assam DIBRUGARH 106 m.	Assam SRIMANGAL 21 m.	Assam SILCHAR 29 m.
January	15	16	31	38	11	20
February	21	16	51	63	38	48
March	111	75	112	103	84	172
April	224	75	257	236	247	385
May	764	533	306	305	401	417
June	1,090	929	384	500	479	589
July	1,601	1,337	457	537	353	521
August	1,214	922	416	451	363	515
September	923	743	301	352	299	389
October	364	229	131	152	179	184
November	40	33	31	34	36	45
December	15	12	15	16	6	11
Total for year (M.A.R.) .	6,380	4,920	2,492	2,792	2,487	3,294
Number of rainy days . .	?	?	128	135	122	137
Number of month with less than 50 mm. . . .	4	4	3	3	4	4
M. A. Humidity . . .	?	?	83	82	81	78
No. of years	?	?	70	40	35	60

The tract is characterised by very favourable distribution of rainfall. Bengal gets a 4-month dry season but may have a higher rainfall.

Rock and Soil.—The type occurs on a variety of soils including typical red tropical soils on outcrops of crystalline rocks. It also flourishes in Tertiary sandstones, etc., on *bhabar* deposits at the foot of the Himalayas, and on the more mature of the alluvial deposits of the big river valleys, the less mature soils tending to carry the deciduous types.

Topography.—The finest forest is now met with on low hills and the gentle slopes at their feet, from the plains almost at sea level upto about 1000-1200 m. where it merges into the montane sub-tropical. The type also occurs on the flat ground of the big alluvial plain but mainly on the higher levels.

5. GENERAL FLORISTICS

Evergreen Dipterocarps are present except in N. Bengal where their absence is difficult to explain—but they tend to be localised in their occurrence. *Dipterocarpus* and *Shorea* are the only genera forming outstandingly big trees. The other characteristic families and genera are very closely similar to those of the southern forests, including *Artocarpus, Syzygium, Mesua ferrea, Meliaceae, Myristica* and *Anacardiaceae. Lauraceae, Magnoliaceae, Quercus* and *Castanopsis* are more important and varied than in the south. Bamboos are more usually present, *Dendrocalamus hamiltonii* being most characteristic and *Melocanna* with *Bambusa tulda* very conspicuous in second growth though primarily associated with more deciduous types of forest. Canes and small palms generally occur, as also sometimes tree ferns. In the shrubby undergrowth, *Rubiaceae* are important but a great variety of families and species occur.

6. SUBDIVISIONS, SUCCESSION, ETC.

Mainly on account of floristic differences, three types are differentiated on a geographical basis. Much further study is needed of the composition and ecology of these forests to permit of a satisfactory analysis of types and an understanding of their relationship.

Cane brakes (1/E1, p. 79) and wet bamboo brake (1/E2, p. 80) occur in badly drained hollows

C1 Assam Valley tropical evergreen forest (Dipterocarpus).

C2 Upper Assam Valley tropical evergreen forest.

  2a Kayea forest.

  2b Mesua forest.

C3 Cachar tropical evergreen forest.

The primary succession on new gravelly alluvium is from *Khair-Sissu* (5/1S2, p. 222) through savannah woodland (moist deciduous riverain) (3/1S1, p. 152), and semi-evergreen riverain (3/1S2, p. 154) to the climax. The deciduous riverain forests normally have a grassy phase, the occurrence of fires in which may lead to savannah forest and this may be long maintained. Cultivation leads to similar results. Locally the savannah forest may develop into very moist sal (3C/C1, p. 127) or a moist deciduous type and thence through wet mixed forest (2B/C1, p. 92) to the climax. Shifting cultivation in hilly country commonly leads to secondary bamboo brakes (2/2S1, p. 102).

In estuaries, there is a succession of tidal forests (4B/TS1, 2; p.163) with littoral forest (4A/L1, p. 155) on sandy ground near the sea front and often delta freshwater swamp (4B/TS4, p. 166) behind.

C1. Assam Valley tropical wet evergreen forest (Dipterocarpus)

NOMENCLATURE.—*Dipterocarpus-Mesua* forest (RAJKHOWA).
Hollong-Nahor forest (WORKING PLANS).
Dipterocarpus-Mesua-Michelia association (ROWNTREE).

DESCRIPTION.—The giant Dipterocarps *D. macrocarpus* and *Shorea assamica* occur scattered and in patches, attaining great girths upto 7 m. and heights upto 50 m. They stand over a closed evergreen canopy at about 30 m. in which *Mesua* (which also attains large girths upto 4 m.) and *Vatica* tend to predominate among a large number of other species. There is also an underwood and a shrub layer but the ground is practically bare. Climbers are abundant as also epiphytes. Palms and canes are generally present.

DISTRIBUTION.—"Over low outcrops of the Naga and Patkoi Hills and the high alluvial deposits of the foothills in the Lakhimpur and the eastern half of the Sibsagar District, on the S. bank of the Brahmaputra......

The type finds its best expression on the undulating old alluvium of the Dehing R., though it is also found at an elevation of.... 610 m. on the foothills of the Naga and Patkoi ranges." (RAJKHOWA).

LOCALITY FACTORS.—The annual rainfall is over 2,300 mm. and upto 3,800 mm. or more, and it is exceptionally well distributed as shown by the data given for Dibrugarh, Sibsagar and Lakhimpur, with only three months (November to January) relatively dry (but even then with heavy dewfall). The monthly maximum does not exceed 32° C and the mean minimum for January is close to 10° C, the absolute minimum being a little under 5° C. From the point of view of temperature the climate is thus definitely subtropical but the favourable moisture distribution and complete absence of frost permits of the development of a forest indistinguishable from that of more southern latitudes.

The soils are largely of recent alluvial formation over Tertiary sandstones and shales, but the latter outcrop on the hills and carry a similar type of forest. For further description, see ROWNTREE, 1954.

ILLUSTRATION.—Plate 6.

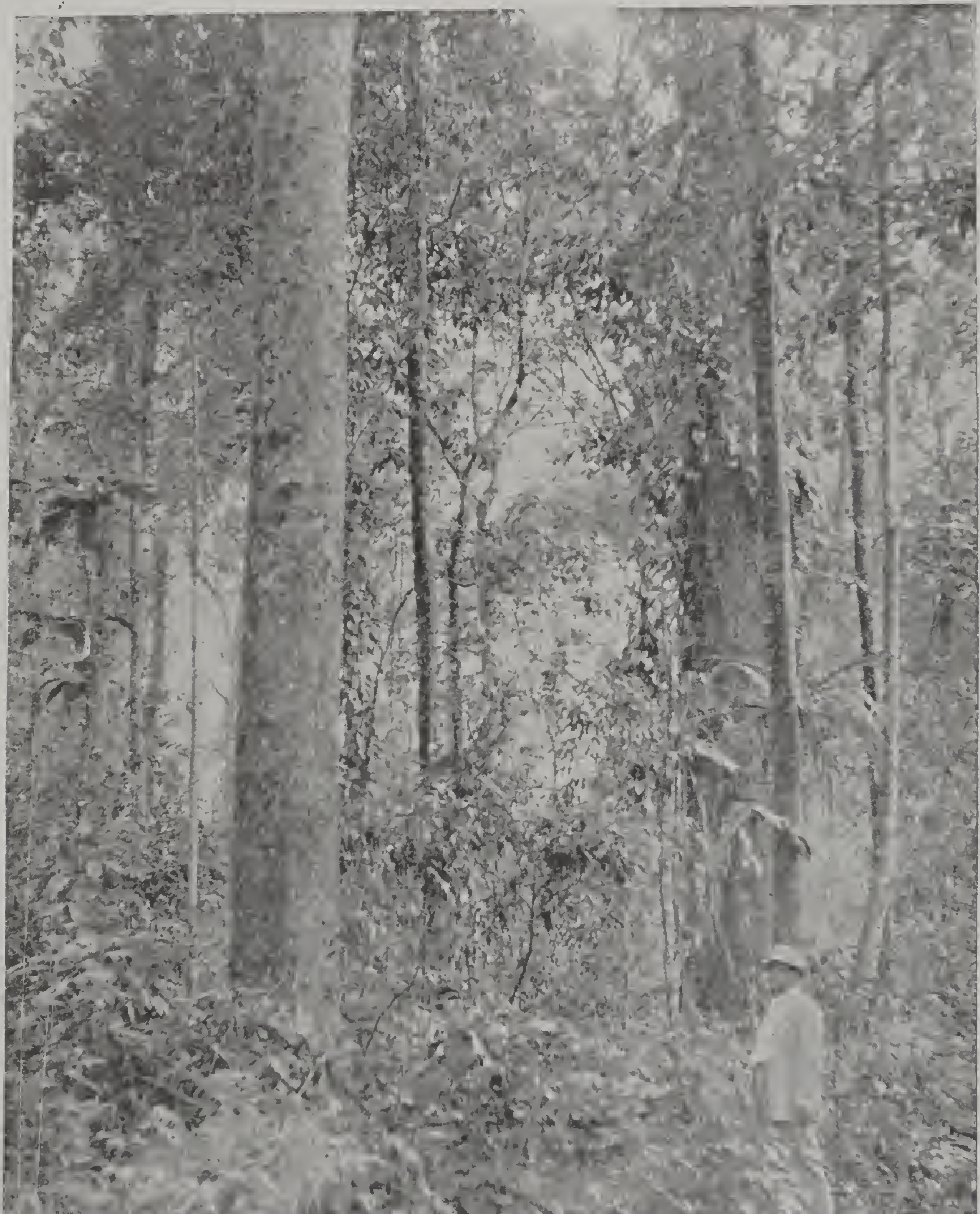
FLORISTICS.—

I. *Dipterocarpus macrocarpus**, *Shorea assamica**, *Mesua ferrea**. *Altingia excelsa*, *Dysoxylum procerum*, *Artocarpus chaplasha*, *Michelia* spp., *Stereospermum personatum*, *Canarium* spp., *Amoora wallichii*.

II. *Vatica lanceaefolia*, *Eugenia* spp., *Garcinia cowa*, *Talauma*, *Myristica*.

IIa. *Dendrocalamus hamiltonii*, *Bambusa pallida*, *Pseudostachyum polymorphum*. *Livistona jenkinsiana*.

III. *Clerodendron*, *Ixora*, *Pinanga*, *Laportea*.



ASSAM VALLEY TROPICAL WET EVERGREEN FOREST

Shorea-Dipterocarpus association, Jeypore reserve, Lakhimpur Division, Assam.

S. K. Seth

IVa. *Alpinia* spp., *Amomum*, *Phrynium*, *Piper*, etc.

V. *Thunbergia grandiflora*, *Ampelocissus* (*Vitis*) *latifolia*, *Dalbergia stipulacea*.

NOTE.—The succession from new alluvium makes an interesting study in U. Assam although it is greatly influenced by human activities and has now usually to pass through a savannah stage (3/1S1, p. 152) with scattered deciduous trees such as *Salmalia*, subject to fires, and through deciduous and semi-evergreen (2B/2S2, p. 96) stages which can be prolonged indefinitely.

C2. Upper Assam Valley tropical evergreen forest

C2a. Kayea forest

DISTRIBUTION.—Extreme E. on the N. bank of the Brahmaputra valley.

FLORISTICS.—Dulong Reserve.

> *Kayea assamica** (69%), *Dysoxylum* spp. (6%), *Echinocarpus* (4%), *Mesua* (3%), *Pterospermum* spp. (7%), *Terminalia chebula* (3%), *Amoora wallichii* (—), *Canarium* spp. (4%).

NOTE.—RAJKHOWA presents this type as a climax formation replacing the *Dipterocarpus-Mesua* type. He does not cite the grounds other than floristic for according it this status, but the complete absence of *Dipterocarpaceae* gives a distinctly different appearance.

C2b. Mesua forest

NOMENCLATURE.—*Mesua*—other species post climax (BOR, ROWNTREE).

DESCRIPTION.—Four-storeyed closed forest averaging 30 m. in height with *Mesua* strongly predominating in the top canopy. Second storey 17 m. high. Climbers rare but *Ficus* frequent.

DISTRIBUTION.—Heavy rainfall areas in foothills of Balipara Frontier Tract.

LOCALITY FACTORS.—High rainfall and humidity; occurring at 200 m. ascending valleys to 800 m; soil well drained, deep and porous.

FLORISTICS.—

I. *Mesua**, *Ailanthus grandis*, *Echinocarpus*, *Michelia doltsopa*, *Quercus lamellosa*, *Tetrameles*, *Dysoxylum hamiltonii*, *Altingia excelsa*, etc.

II. *Aphanamixis polystachya*, *Beilschmiedia*, *Gynocardia*, *Sapium baccatum*, *Vatica*, etc.

IIa. *Dendrocalamus hamiltonii*.

III. *Garcinia cowa*, *Pandanus furcatus*, *Miliusa*, *Leea*, etc.

IVa. *Psychotria* spp., *Strobilanthes*, *Tacca*, *Zingiber*, etc.

V. *Combretum flagrocarpum*, *Mucuna nigricans*, *Vitis* spp.

NOTE.—Would appear to be a climax type but may be determined by local site factors.

C3. Cachar tropical evergreen forest

NOMENCLATURE.—*Mesua-Dipterocarp-Palaquium* formation (RAJKHOWA).

Mixed evergreen (WORKING PLANS)
cf. RAJKHOWA, p. 522

DESCRIPTION.—The type does not differ markedly in structure from the foregoing. Giant trees are perhaps rather fewer and it is recorded that climbers occur far less frequently than in U. Assam.

DISTRIBUTION.— The lower hills and hill slopes of the Cachar hills and the Khasi and Jainti hills round the Surma valley. The evergreen forest is now mainly confined to northern and eastern aspects, steep uncultivable slopes, and rocky and shady stream banks, owing to the very heavy incidence of shifting cultivation.

LOCALITY FACTORS.—Climatological data are given for Silchar which is a quite representative station. As noted above, the type is now largely restricted to hilly ground and special sites unsuitable for cultivation. The Surma valley is an alluvial tract and the surrounding hills are chiefly of U. Tertiary sandstones. The valley is dotted with isolated hills called *telas* of old alluvial red sand, clay and gravel "often highly indurated with ferruginous cement".

ILLUSTRATIONS.—Not traced.

FLORISTICS.—A good many important species occur here which are absent in U. Assam; among them may be noted *Dipterocarpus turbinatus* and *Palaquium polyanthum* as well as the bamboo *Melocanna bambusoides*. Similarly *Shorea assamica* and other typical trees of U. Assam are absent from Cachar.

(i) *Inner Line Reserve, Cachar Division* (RAJKHOWA)—

I & II. *Palaquium** (20%), *Diospyros topiosa* (9%), *Cynometra polyandra* (8%), *Dipterocarpus turbinatus* (7%), *Mesua* (7½%), *Eugenia* spp. (8%), *Euphoria longana* (8%), *Sapium baccatum* (3½%), *Vatica lanceaefolia* (3%), *Canarium* spp. (3%), *Hydnocarpus kurzii* (2½%), *Heritiera acuminata*, *Persea owdenii*, *Kayea floribunda*. (Percentages of trees over 3 ft. girth).

NOTE.—"Shifting cultivation and heavy exploitation of the *Dipterocarpus* have destroyed much of this formation, so that it is found in localized patches only".

(ii) *Loharband, Cachar, L. Assam.* (ROWBOTHAM)—

I & II. *Dipterocarpus turbinatus**, *Artocarpus chaplasha*, *Mangifera sylvatica*, *Persea owdenii*, *Eugenia* spp., *Palaquium polyanthum**, *Amoora* spp., *Mesua ferrea*, *Calophyllum polyanthum*, *Aquilaria agallocha*, *Sterculia* spp., *Canarium* spp., *Podocarpus neriifolia.*

IIa. *Melocanna bambusoides*, *Bambusa balcooa*, *Neohouzeaua dullooa*, or without bamboo.

III. Evergreen undergrowth with a few palms.

IV. Climbers relatively few, *Entada phaseoloides*, *Acacia* spp., *Combretum* spp., *Delima.*

NOTE.—The area where this forest should be the climatic climax has been enormously affected by shifting cultivation, particularly in the hills where it is still extensively practised. The abandoned *jhums* if left long enough become restocked mainly with deciduous species and if protected from jhuming and burning fairly quickly revert to a closed evergreen type from which further progress to the climatic climax would presumably take place.

Natural regeneration of the evergreens is said to be better than in U. Assam; in particular young *Palaquium* forms almost pure woods (perhaps an indication of human interference).

Eupatorium odoratum has invaded the whole tract and comes up densely wherever the canopy is broken.

GENERAL EDAPHIC AND SERAL TYPES OF WET EVERGREEN FORESTS

E1. Cane brakes

DESCRIPTION.—An impenetrable thorny thicket sometimes with a few tall trees standing over it, sometimes without. The stems are typically trailing and may be 60 m. or more long, but some species are more or less erect.

DISTRIBUTION.—Throughout the evergreen and semi-evergreen climaxes and locally in moist deciduous forest.

LOCALITY FACTORS.—Occurs in wet hollows extending outwards to various distances, becoming more conspicuous with heavier and better distributed rainfall, *i.e.* in the wet tropical evergreen. The soil is permanently wet and usually fine clay, very rich in humus.

ILLUSTRATION.—Cf. Plate 33.

FLORISTICS.—*Calamus* spp. and sometimes the creeping bamboo *Neohouzeaua.* A few palms such as *Licuala* and *Zalacca.* The species vary with locality permitting differentiation of a number of forms.

NOTE.—Once the creeping canes are in possession of a site, they make it almost impossible for trees to push through but they require a constant and abundant water supply for optimum development. *Calamus tenuis* brakes extend well into the moist sal forests in Uttar Pradesh.

E2. Wet bamboo brakes

DESCRIPTION.—The brakes are often very dense, even if the bamboos grow in clumps. The bamboos tend to be of the smaller types rather than the big clumped species

DISTRIBUTION.—Throughout the tropical evergreen tracts of S. India and Andamans.

LOCALITY FACTORS.—Wet bamboo brakes are usually found along streams or on badly drained hollows more or less displacing the tree forest, whilst cane brakes replace them in the wettest sites.

ILLUSTRATION.—Plate 7.

FLORISTICS.—

(i) *Andamans.*—

I. *Dipterocarpus* spp.

IIa. *Oxytenanthera* sp., *Bambusa sehizostachyoides.*

(ii) *South India.*—

I. Trees of the tropical forest.

IIa. *Ochlandra* spp.

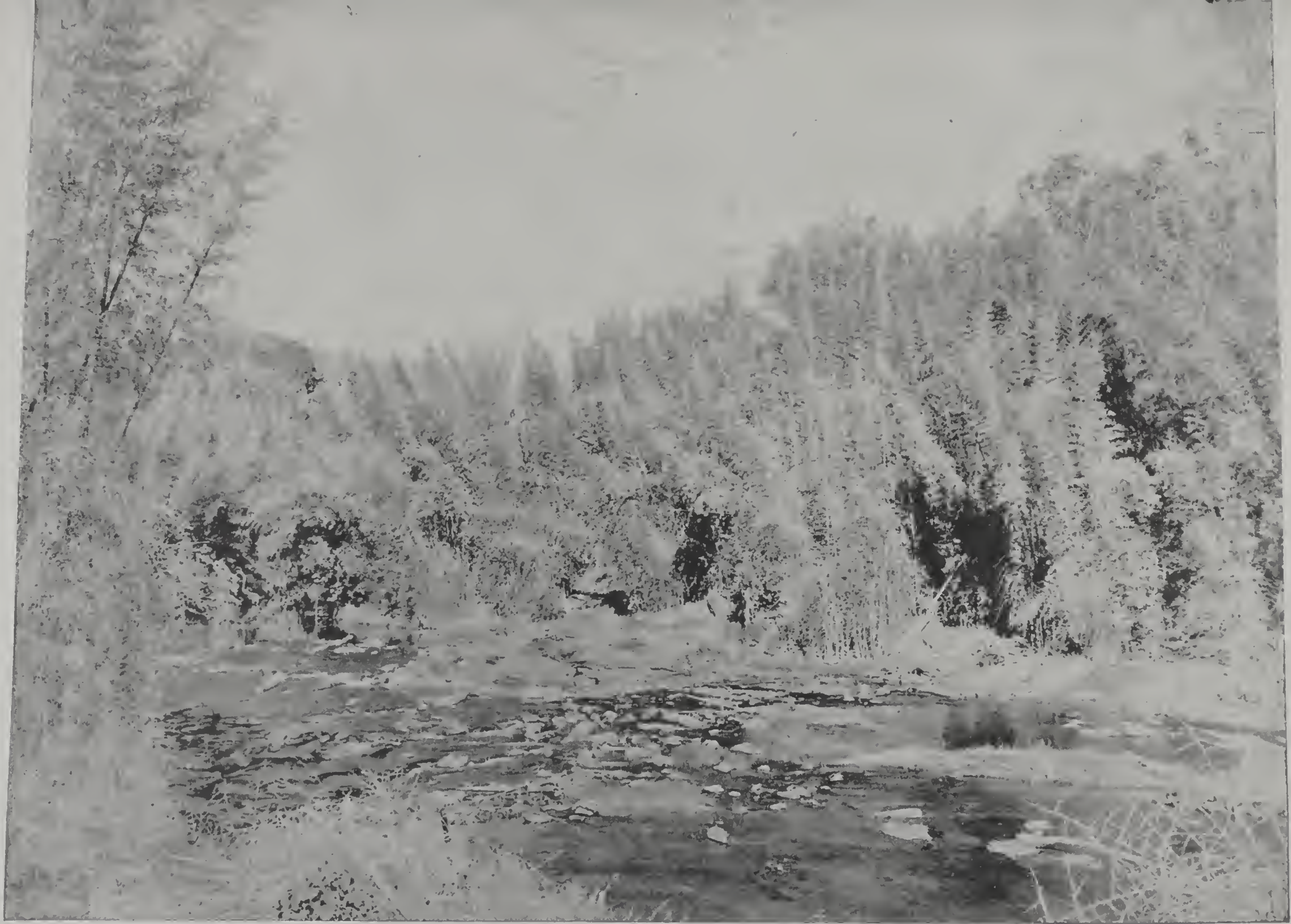
NOTE.—Species of *Ochlandra* (reeds) frequently occur in damp sites in the evergreen and semi-evergreen forests and are prone to extend considerably if the canopy is broken from any cause. As, however, the major occurrences are mostly in the higher hills, these are described under the subtropical vegetation types, *vide* p. 256.

2S1. Pioneer Euphorbiaceous scrub

In most moist evergreen and semi-evergreen forests, if a heavy or clear felling is made and the area is then left to its natural regrowth, it very commonly occurs that a cover of quick growing but short lived small trees is quickly established. The *Euphorbiaceous* genera *Macaranga*, *Mallotus* and *Trema* usually predominate as a first stage in the secondary sere providing shade and shelter under which the slower and less adaptable species of the latter stages become established and ultimately push through and supplant the pioneers.

FLORISTICS.—

(i) *Assam* (ROWNTREE)—



WET BAMBOO BRAKES

Mature consociation of *Bambusa arundinacea* along river bank, Kuriarki, Cochin, Kerala.

H. G. Champion

Macaranga-Mallotus-Trema association (secondary sere ultimately progressing to *Dillenia-Bischofia* association).

I. *Actinodaphne obovata*, *Anthocephalus cadamba*, *Duabanga grandiflora*, *Litsea monopetala* (all occasional).

II. *Macaranga denticulata**, *Mallotus albus**, *Trema orientalis**, *Bauhinia purpurea*, *Clausena indica*, *Croton joufra*, *Erythrina suberosa*, *Alangium chinense*.

III/IV. *Alpinia mollucensis*, *Casearia vereca*, *Laportea crenulata*, *Melastoma malabathricum*, *Osbeckia crinita*, *O. nepalensis*, *Phrynium* sp.

(ii) *South Kerala* (LEGRIS and VIART)—

I/II. *Macaranga indica**, *Mallotus philippensis**, *Sterculia urens*, *Vernonia travancorica*, *Trema orientalis**, *Grewia tiliaefolia*, Bamboos.

GROUP 2. TROPICAL SEMI-EVERGREEN FORESTS

Sub-group 2A. Southern Tropical Semi-evergreen Forests

1. NOMENCLATURE

See corresponding entries under individual types below.

2. GENERAL DESCRIPTION

This type is very variable and difficult to define except in comparative terms, being intermediate between the tropical evergreen and moist deciduous forms but usually including groups or patches fairly typical of both. It accordingly forms a closed high forest the dominant trees sometimes running to big dimensions but is usually inferior to Type 1a, and includes both evergreen and deciduous trees—the former predominating—in intimate mixture but with a definite tendency to gregarious occurrence. The number of species is high but less so than in the true evergreen many of the biggest evergreens being absent. Buttressed stems continue to be frequent and occur in both evergreen and deciduous species (e.g. *Elaeocarpus* spp. and *Salmalia*). Bark tends to be thicker and rougher and cauliflory rarer. The general canopy is typically less dense than in the true evergreen and the evergreen undergrowth rather more copious; climbers tend to be very heavy. Bamboos are usually present but less prevalent than in the moist deciduous. Epiphytes are abundant including many ferns and orchids.

3. DISTRIBUTION

The type occurs throughout the moister parts of southern tropics always in association with the true evergreen, but it does not occupy a very large area as there are but few extensive tracts where the moisture conditions are adequate for its development but at the same time inadequate for an evergreen climax. This is particularly marked in the Western Ghats where the rainfall gradient is very steep. A suitable rainfall is also met with just north of Bombay, near Goa, and south of Cochin over areas large enough to develop a typical vegetation.

It is also frequently encountered as an edaphic subclimax to tropical evergreen on shallow porous soils.

4. LOCALITY FACTORS

Temperature.—The mean annual temperature is about 26° C, the January mean 21°—24° C, and mean maximum about 16° C whilst the mean extreme minimum is not below 10° C.

Temperature Data (centigrade)

Southern tropical semi-evergreen forests

Month	Mysore KARWAR 4 m.			Kerala MANGALORE 22 m.		
	Mean	Mean max.	Mean min.	Mean	Mean max.	Mean min.
January	25·8	31·8	19·7	26·6	31·7	21·4
February	25·5	30·6	20·3	26·8	31·1	22·5
March	26·7	30·9	22·4	28·2	32·0	24·3
April	27·8	31·3	24·4	29·4	32·9	25·8
May	28·7	31·4	25·9	29·3	32·7	26·6
June	26·2	28·3	24·0	26·6	29·2	23·8
July	25·8	27·7	24·0	26·1	28·7	23·5
August	25·6	27·4	23·8	26·2	28·8	23·4
September	26·4	28·9	23·9	26·3	29·1	23·5
October	26·7	29·6	23·8	26·8	29·9	23·7
November	25·4	31·1	19·7	27·1	31·0	23·1
December	25·2	31·3	19·1	26·8	31·7	21·4
M. A. T.	26·3	..	..	27·2	..	..
Annual mean max.	30·0	..	..	30·7	..	..
Highest record	?	..	..	37·8	..	..
Annual mean min.	22·6	..	..	23·6	..	..
Lowest record	?	..	..	16·7	..	..
No. of years	upto 1955	..	..	60	..	..

Rainfall.—As the occurrence of the type seems to be determined in many places more by edaphic than climatic causes, the records for stations in or near it show a considerable range. The typical rainfall is probably between 2000 mm. and 2500 mm. rarely less, but frequently much more. Karwar (on the west coast) and Yellapur (at the top of the Ghat above Karwar) are more or less typical for the Western Ghats.

Rainfall (millimetres)

Southern tropical semi-evergreen forests

Month	Coorg SOMVARPET 1131 m.	Mysore SAGAR (Shimoga) 515 m.	Mysore KARWAR 4 m.	Mysore YELLAPUR 565 m.
January	3	2	1	1
February	3	2	1	1
March	12	9	0	8
April	64	44	12	35
May	103	63	86	56
June	355	399	951	510
July	757	747	944	964
August	439	394	542	554
September	153	141	276	184
October	172	142	147	136
November	83	41	42	27
December	17	8	6	5
Total for year (M.A.R.)	2,183	1,994	3,006	2,495
No. of rainy days	110	98	104	104
No. of months with less than 50 mm.	4	5	6	5
M. A. humidity	?	?	80	?
No. of years	50	71	57	63

Rock and Soil.—Tropical red soils, for the most part, overlying a variety of rocks mainly crystalline rocks in the W. Peninsula.

Topography.—Almost entirely on low hilly or undulating ground though also occurring on fairly flat plateau country.

5. GENERAL FLORISTICS

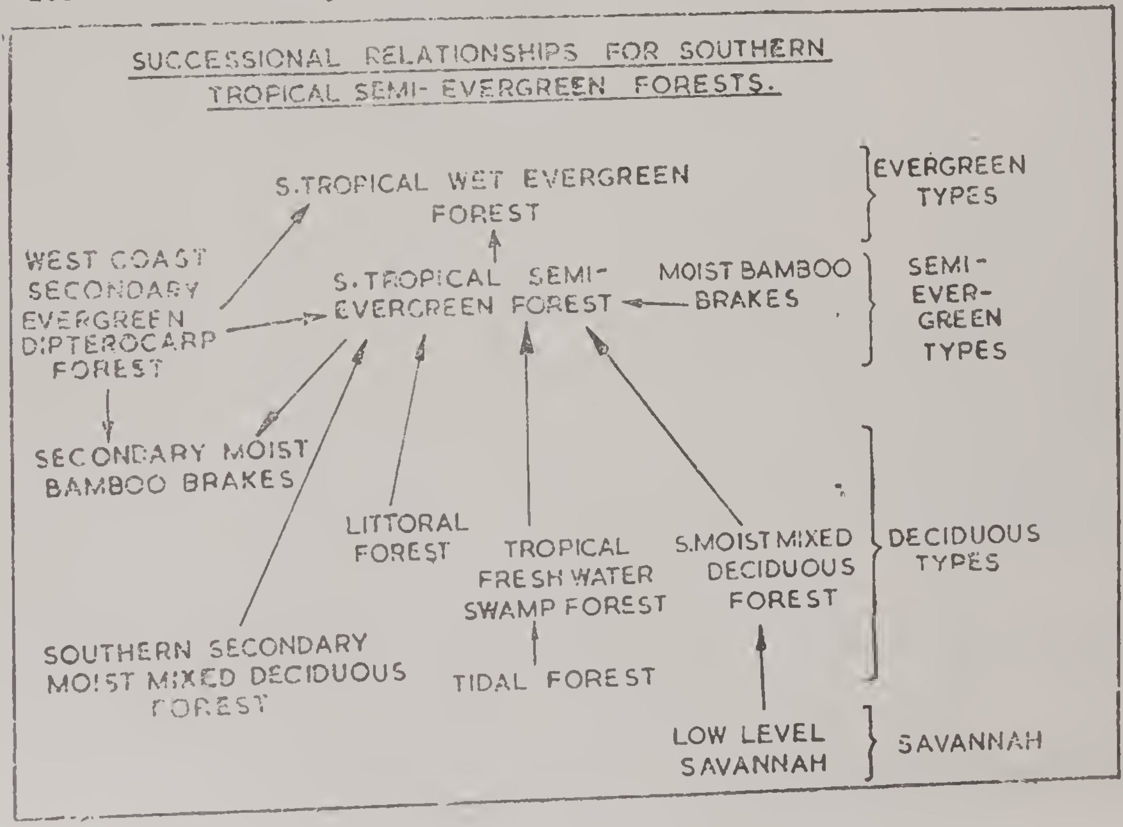
In the upper canopy, *Xylia* and *Terminalia* are most typical but Dipterocarps also frequently occur (*Dipterocarpus*, *Balanocarpus*, *Hopea*). The middle canopy is made up of evergreen *Myrtaceae*, *Schleichera oleosa*, *Lauraceae*, etc. Bamboos, when present, are *Bambusa arundinacea* (W), *B. polymorpha* and *Cephalostachyum pergracile* (E). The ground cover is largely made up of evergreen shrubs including various *Rubiaceae* and *Acanthaceae*.

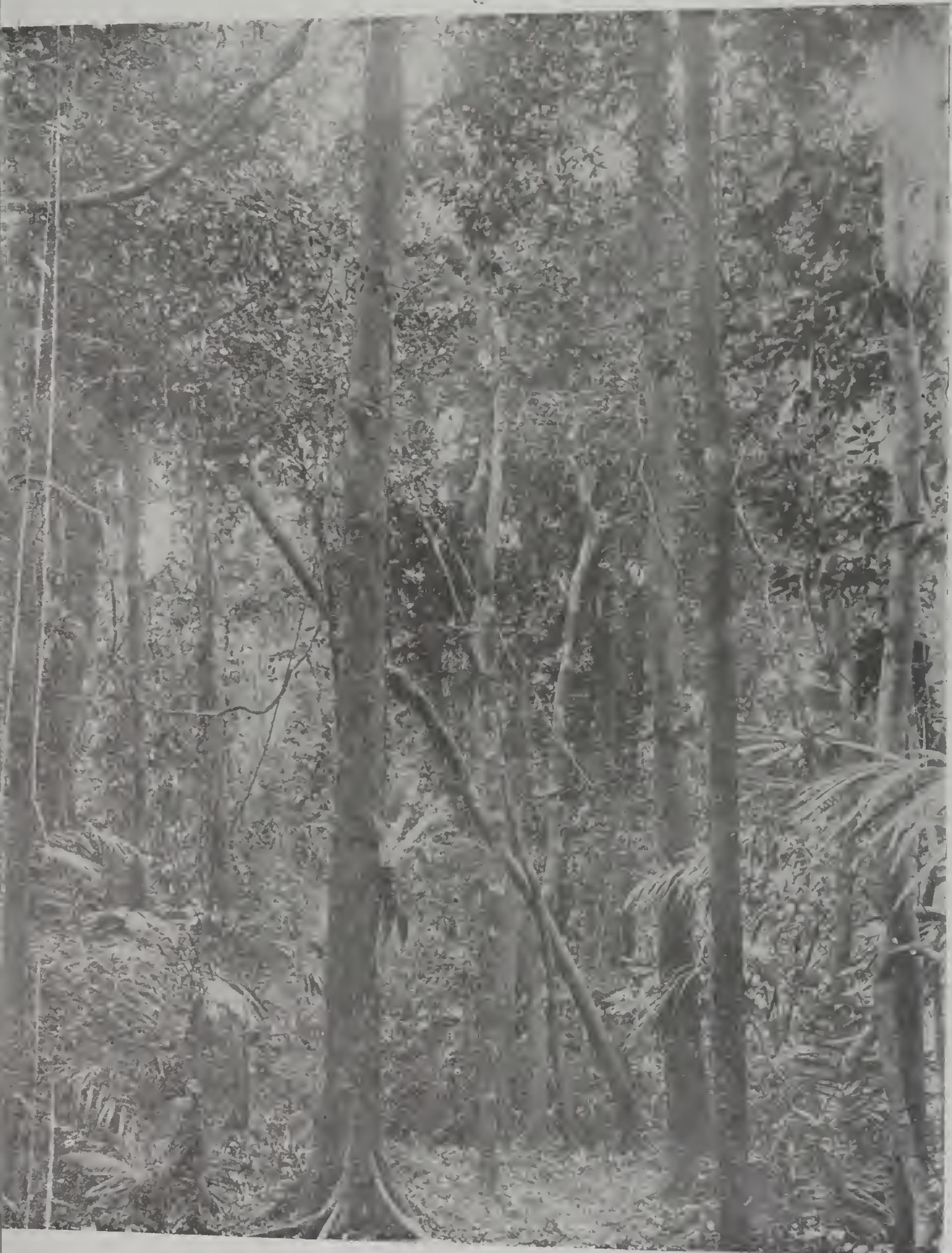
6. SUBDIVISIONS, SUCCESSIONS, ETC.

Only two forms call for separation on present information, one of them being conditioned primarily by the hard more or less lateritic soil and frequently also found under the climatic conditions appropriate to the evergreen types.

The primary seres are indistinguishable from those of the evergreen forests and include beach, tidal swamp and riverain types. Clearing is again likely to result in the development of secondary bamboo brakes in hilly country, whilst elsewhere secondary semi-evergreen (2A/2S1, p. 87) and secondary moist deciduous (3B/2S1, p. 119) are found.

C1 Andamans semi-evergreen forest.
C2 West Coast semi-evergreen forest.
C3 Tirunelveli semi-evergreen forest.
2S1 West Coast secondary evergreen Dipterocarp forest.

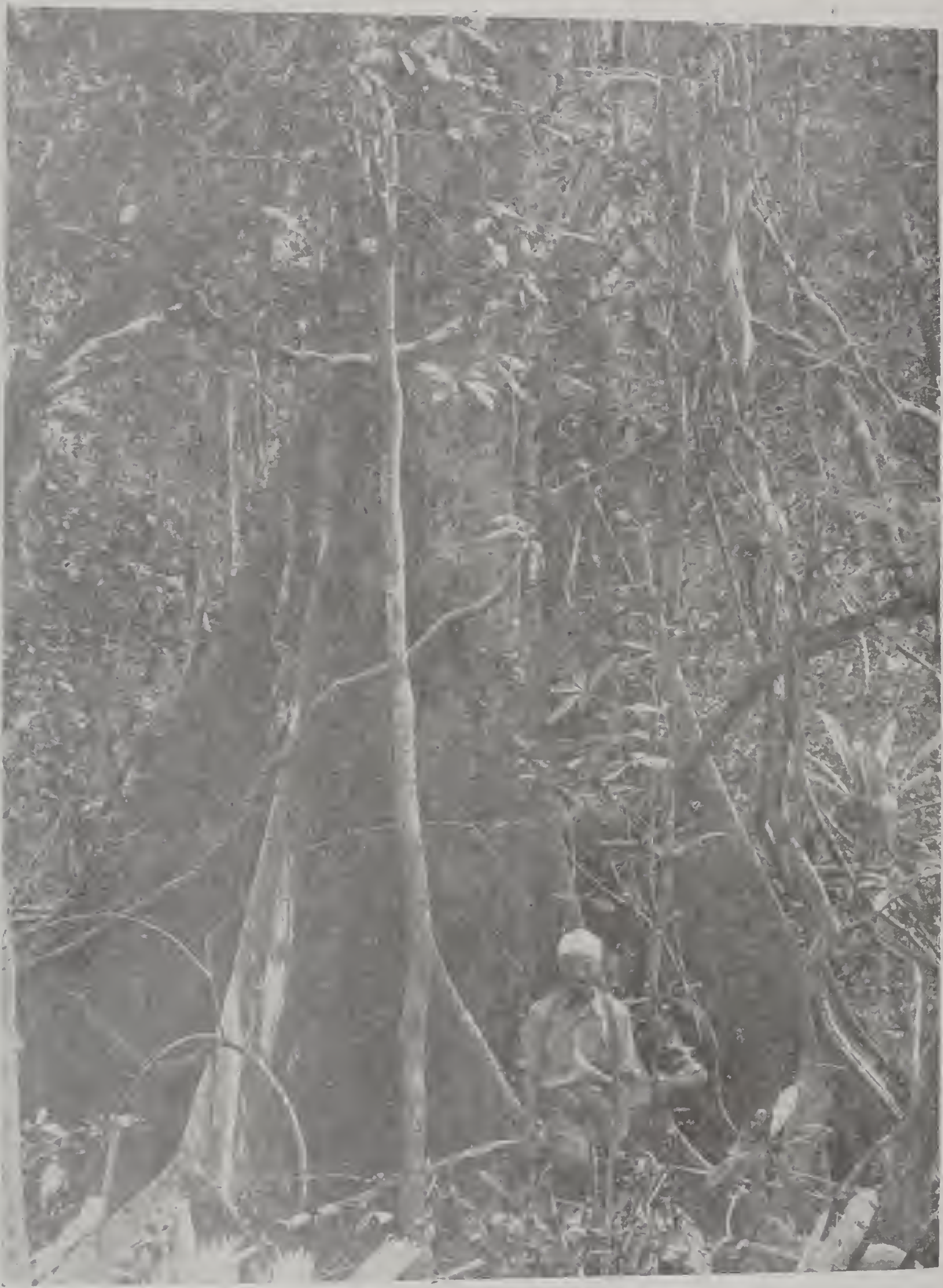

SUCCESSIONAL RELATIONSHIPS FOR SOUTHERN TROPICAL SEMI-EVERGREEN FORESTS.
S. TROPICAL WET EVERGREEN FOREST
EVERGREEN TYPES
WEST COAST SECONDARY EVERGREEN DIPTEROCARP FOREST
S. TROPICAL SEMI-EVERGREEN FOREST
MOIST BAMBOO BRAKES
SEMI-EVERGREEN TYPES
SECONDARY MOIST BAMBOO BRAKES
LITTORAL FOREST
TROPICAL FRESH WATER SWAMP FOREST
S. MOIST MIXED DECIDUOUS FOREST
DECIDUOUS TYPES
SOUTHERN SECONDARY MOIST MIXED DECIDUOUS FOREST
TIDAL FOREST
LOW LEVEL SAVANNAH
SAVANNAH



ANDAMANS SEMI-EVERGREEN FOREST

A group of mixed evergreen and deciduous trees, including *Terminalia bialata* with large climbers, canes, epiphytic ferns and aroids. Middle Andamans.

H. G. Chambion



ANDAMANS SEMI-EVERGREEN FOREST

A large buttressed *Parishia insignis* carrying a tangle of woody climbers and epiphytic ferns. Middle Andamans.

H. G. Champion

C1. Andamans semi-evergreen forest

NOMENCLATURE.—Low evergreen forest (CHENGAPPA).

DESCRIPTION.—A luxuriant type of forest with many giant trees which include both deciduous and evergreen species often intimately mixed but frequently in groups, particularly the evergreens. Climbers are often heavy. Bamboos may or may not be present. CHENGAPPA describes it as the densest forest in the Andamans.

DISTRIBUTION.—Andamans in the main valleys.

LOCALITY FACTORS.—The chief characteristic is the immature alluvial soil sufficiently old and raised above flood level to be able to progress to the climatic climax, but with a good subsoil water supply and well drained soil.

ILLUSTRATIONS.—Plates 8 and 9.

FLORISTICS. (CHENGAPPA)—

I. *Dipterocarpus alatus**, *D. pilosus**, *Pterygota alata*, *Pterocymbium tinctorium*, *Sterculia campanulata*, *Terminalia bialata**, *T. procera**, *Albizzia chinensis*, *A. lebbek*, *Calophyllum soulattri*, *Salmalia insignis*, *Artocarpus lakoocha*, *A. chaplasha*, *Pterocarpus dalbergioides*.

II. *Lagerstroemia hypoleuca*, *Dillenia pentagyna*, *Dracontomelum mangiferum*, *Pometia pinnata*, *Myristica irya*, *Pisonia excelsa*, *Litsea panamonja*, *Xanthophyllum andamanicum*, *Fragraea morindaefolia*, *Talauma andamanica*, *Garcinia andamanica*, *Aporosa villosula*, *Licuala peltata*, *Caryota mitis*, *Areca triandra*.

IIa. Usually no bamboos. *Oxytenanthera* sp. (1).

III. *Saprosma ternatum*, *Maesa andamanica*, *Micromelum pubescens*, *Clerodendrum viscosum*, *Leea indica*, *Clinogyne grandis*.

V. *Dinochloa andamanica*, *Thunbergia laurifolia*, *Buettneria andamanensis*, *Combretum extensum*, *Daemonorops*, *Calamus*.

NOTES.—The type is economically the most important of the Andamans, and owing to its accessibility, it is being steadily cleared or worked over.

C2. West Coast semi-evergreen forest

DESCRIPTION.—Intermediate between eastern tropical evergreen and the moist deciduous forests with evergreen and deciduous dominants usually intimately mixed though extensive consociations are met with, notably of *Xylia*. Lower storey mainly evergreen. *Bambusa arundinacea* is the typical bamboo.

DISTRIBUTION.—In the W. Ghats, generally between the wet evergreen and moist deciduous but usually only as a narrow strip which has often been destroyed (especially at the north end) or greatly altered by biotic influences, LOCALITY FACTORS.—Rainfall from 2,000-2,500 mm. locally much more. Mostly on hill slopes from 450 to 1,050 m. but also on the plains.

ILLUSTRATION.—Plate 10.

FLORISTICS.—

(i) *S. Kanara, Mysore.*—

I. *Terminalia paniculata**, *Diospyros* spp., *Lagerstroemia lanceolata*, *Holigarna arnottiana*, *Lophopetalum wightianum*, *Machilus macrantha*, *Cinnamomum* sp., *Hopea parviflora*, *Artocarpus hirsuta*.

II. *Elaeocarpus serratus*, *Mallotus philippensis*, *Diospyros assimilis*, *Ixora arborea*.

III. *Webera*, *Strobilanthes* spp., *Ixora malabarica*.

IV. Climbers and canes numerous.

(ii) *Wynaad and Palghat, Kerala.*—

I. *Artocarpus hirsuta*, *Salmalia malabarica*, *Vitex altissima*, *Tetrameles nudiflora*, *Acrocarpus fraxinifolius**, *Hopea parviflora**, *Lagerstroemia lanceolata*, *Vateria indica*, *Anthocephalus cadamba*, *Xylia xylocarpa*, *Terminalia tomentosa*, *Cedrela toona*, *Grewia tiliaefolia*, *Dalbergia latifolia*, *Pterospermum rubiginosum*, *Radermachera xylocarpa*, *Mesua ferrea*, *Adina cordifolia*, *Holoptelea integrifolia*, *Pterocarpus marsupium*, *Sterculia guttata*.

II. *Hydnocarpus laurifolia*, *H. alpina*, *Bischofia javanica*, *Mallotus philippensis*, *Kydia calycina*, *Schleichera oleosa*, *Evodia lunu-ankenda*.

IIa. *Bambusa arundinacea*, *Ochlandra* sp.

(iii) *Trivandrum, Kerala.*—

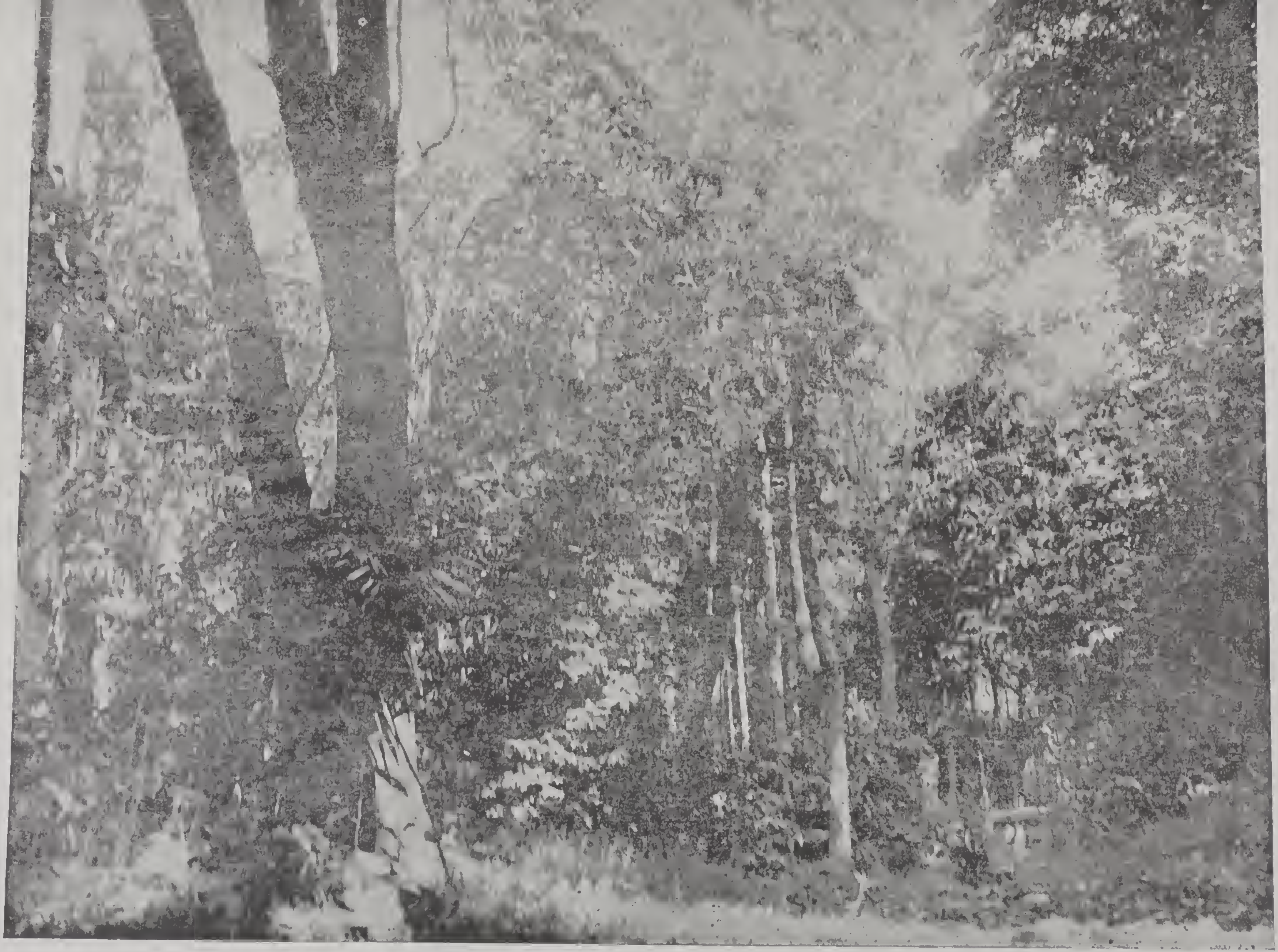
I. *Artocarpus hirsuta* (o), *Hopea parviflora**(f), *Adina cordifolia* (o), *Lagerstroemia lanceolata* (o), *Terminalia paniculata** (a), *T. tomentosa** (a), *Salmalia malabarica* (o), *Tetrameles nudiflora* (la), *Vitex altissima* (f), *Holoptelea integrifolia* (o), *Vateria indica* (lf), *Lophopetalum* (f), *Pterocarpus marsupium* (f), *Calophyllum elatum* (la), *Machilus macrantha** (a), *Grewia tiliaefolia* (o), *Terminalia bellerica* (o).

II. *Polyalthia fragrans*, *Canarium strictum*, *Cinnamomum zeylanicum*, *Aporosa lindleyana*, *Mallotus philippensis*, *Xanthophyllum flavescens*, *Emblica officinalis*, *Bridelia retusa*, *Albizzia odoratissima*.

IIa. Bamboos and reeds very common.

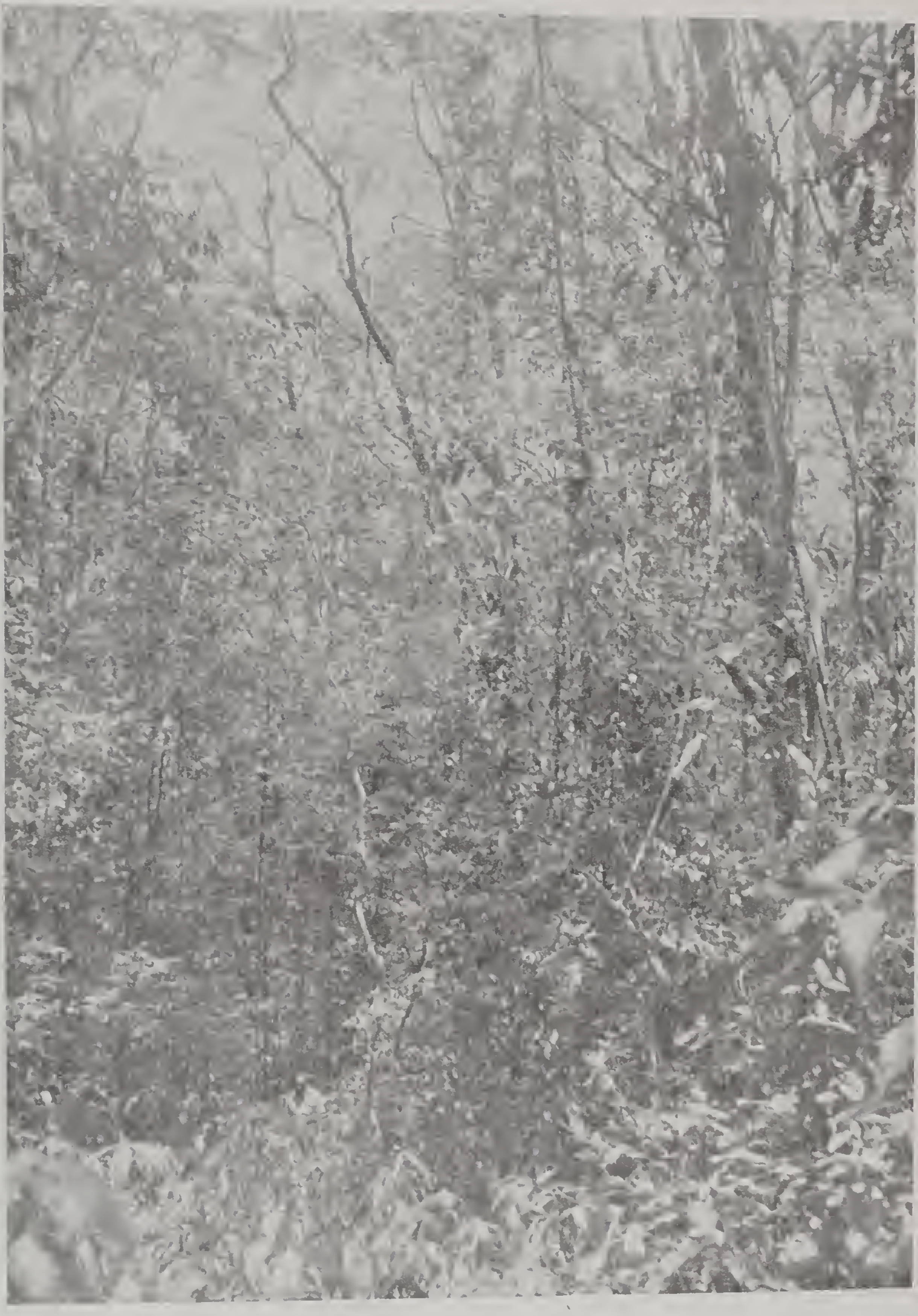
III. *Clerodendron*, *Glycosmis pentaphylla*, *Strobilanthes* sp.

IV. *Entada phaseoloides*, *Butea parviflora*, *Strychnos colubrina*, *Dioscorea* sp.



WEST COAST SEMI-EVERGREEN FOREST
With *Lagerstroemia lanceolata*, *Salmalia malabarica*, *Terminalia paniculata* etc.
near Poonmudi, Kerala.

S. K. Seth



WEST COAST SECONDARY EVERGREEN DIPTEROCARP FOREST

Dense *Hopea* growth on tea estate abandoned about 40 years earlier. Chirikala, Kerala.

S. K. Seth

C3. Tirunelveli semi-evergreen forest

DESCRIPTION.—Closed forest rarely exceeding 30 m. in height, with a two or three storeyed canopy which is rather open February to April. Epiphytic moss and lichens are not conspicuous but orchids occur. Climbers fairly numerous and canes are abundant at the higher levels.

DISTRIBUTION.—On the eastern slopes of the southern W. Ghats between 250 and 550 m. or even 1,000 m. between the wet evergreen above and the moist deciduous below, as a relatively narrow strip.

LOCALITY FACTORS.—Rainfall almost equally from both monsoons, 1,900-2,500 mm. with no rain from Jan.-April. Soil red gravelly and semi-laterite, well drained.

FLORISTICS.—

Tirunelveli Division, (LASRADO)—

I. *Hopea (Balanocarpus) utilis**, *Hopea parviflora*, *Pterospermum* spp., *Kingiodendron pinnatum*, *Stereospermum personatum*, *Dalbergia latifolia*, *Chukrasia*. *Artocarpus heterophyllus*.

II. *Aglaia* spp., *Euphoria (Nephelium) longana*, *Drypetes venusta*, *Bischofia*, *Carallia*, *Diospyros* spp.

III. *Strobilanthes* spp., *Glycosmis*.

2S1. West Coast secondary evergreen Dipterocarp forest

DESCRIPTION.—Nearly pure forest of evergreen *Dipterocarpaceae* of relatively poor development but with an even and typically dense canopy, without a definite middle storey but with an undergrowth of evergreen shrubs.

DISTRIBUTION.—On the coastal plain below the W. Ghats.

LOCALITY FACTORS.—A high rainfall of over 2,500 mm. and a hot equable climate typified by Mangalore (p. 82). Stiff red tropical soils often lateritic on fairly level country intersected by a network of eroded depressions.

ILLUSTRATION.— Plate 11.

FLORISTICS.—

(i) *Pilarkhan, N. Mangalore Division.*—

I. *Hopea parviflora** (a), *H. wightiana** (la), *Vateria indica* (la), *Diospyros microphylla* (f).

II. *Aporosa lindleyana* (a), *Olea dioica* (f).

IIa. No bamboo.

III. *Memecylon* sp. (a), *Syzygium caryophyllatum* (a), *Rubiaceae* (a) and *Acanthaceae* (f).

V. *Calycopteris* (f).

NOTE.— This is an easily recognizable form of residual forest on the coast owing its existence entirely to human activities among which lopping for green manure is most important. The poorer soils revert to deciduous forest, but the last stages of denudation are typically evergreen scrub (*Ixora coccinea*, *Syzygium caryophyllatum*, *Phoenix*) and finally short tufted grass with scattered bushes of *Calycopteris*.

(ii) *Kerala*—

I./II. *Polyalthia fragrans*, *Vateria indica*, *Knema attenuata*, *Tetrameles nudiflora*, *Hopea parviflora**, *Vitex altissima*, *Xylia xylocarpa*, *Salmalia malabarica*, *Glochidion* sp., *Macaranga peltata*, *Kingiodendron pinnatum*.

IIa. Heavy undergrowth of reeds (*Ochlandra* sp.*).

Sub-group 2B. Northern Tropical Semi-evergreen Forests

1. NOMENCLATURE

General	Tropical evergreen rain forest (in part) (SCHWEINFURTH).
Assam	Riverain semi-evergreen forest of U. Assam. *Terminalia-Morus* association (ROWBOTHAM).
	Semi-evergreen forest of S. Cachar.
Bengal	Wet mixed forest of N. Bengal. Wet sal forest of N. Bengal (part).
Orissa	Evergreen forest (HAINES).

2. GENERAL DESCRIPTION

Dense storeyed high forest 24-36 m. high in which evergreens predominate particularly in the lower canopy but in which an appreciable proportion of the canopy, including some of the most typical species are deciduous for a varying but usually short period during the dry season. In comparison with the southern form, the tendency to the gregarious habit is still more marked, and the flora is not so rich, but the differences on the whole are small. Bamboos are often absent but occur freely in some localities (only one or two species). Canes are usual along water courses and climbers are common.

3. DISTRIBUTION

The type is developed in the moderately heavy to heavy rainfall areas of Assam and Bengal, extending down the east coast of the peninsula to Puri in Orissa.

4. LOCALITY FACTORS

These forests occur under habitat conditions widely overlapping those of groups 1B and 3B and the representative localities, for which data are reproduced below, also support both these groups; it is probable however that the climatic climax on average sites would fall under 2B.

Temperature Data (centigrade)

Northern Tropical Semi-evergreen Forest.

Month	Assam DHUBRI 35 m.			Assam TEZPUR 79 m.			Assam SILCHAR 29 m.			West Bengal JALPAIGURI 83 m.		
	Mean	Mean max.	Mean min.	Mean	Mean max.	Mean min.	Mean	Mean max.	Mean min.	Mean	Mean max.	Mean min.
January . .	17·4	23·0	11·8	17·3	23·2	11·4	18·4	25·6	11·3	17·1	23·6	10·6
February . .	19·2	25·0	13·4	19·0	24·7	13·3	20·1	27·0	13·2	18·6	24·9	12·1
March . .	23·7	30·0	17·3	22·7	28·6	16·8	23·8	30·3	17·2	22·4	29·6	15·7
April . .	26·2	31·2	21·2	24·7	29·5	19·9	25·8	31·1	20·4	26·0	31·9	20·1
May . . .	26·3	29·9	22·8	26·4	30·4	22·4	27·1	31·5	22·6	27·3	31·9	22·6
June . .	27·2	29·8	24·5	28·1	31·4	24·7	28·2	31·8	24·6	27·9	31·4	24·3
July . .	27·8	30·0	25·7	28·6	31·9	25·3	28·7	32·3	25·1	28·3	31·4	25·2
August . .	28·0	30·2	25·8	28·7	31·9	25·4	28·4	31·9	24·9	28·4	31·6	25·2
September .	27·5	29·8	25·2	28·2	31·6	24·7	28·3	32·1	24·6	27·8	31·2	24·4
October . .	25·9	29·1	22·7	26·0	30·2	21·8	26·8	31·3	22·3	25·8	30·4	21·3
November .	22·1	36·3	17·8	21·8	27·2	16·4	23·4	29·4	17·5	21·9	27·8	16·0
December .	18·3	23·4	13·2	18·2	24·0	12·3	19·6	26·6	12·6	18·3	24·8	11·8
M. A. T. .	24·2	..	..	24·2	..	..	24·9	..	..	23·9	..	..
Annual mean max. .	28·2	..	..	28·7	..	..	30·1	..	..	29·2	..	..
Highest record	41·1	..	..	38·3	..	..	39·4	..	..	40·0	..	..
Annual mean min. . .	20·1	..	..	19·6	..	..	19·7	..	..	19·1	..	..
Lowest record .	2·8	..	..	6·1	..	..	5·0	..	..	2·2	..	..
No. of years .	60	..	..	40	..	..	60	..	..	55	..	..

Rainfall and Humidity.—Mean annual rainfall is typically about 2,000 mm. but ranges from 1,500 to 3,000 mm. or more varying greatly with topography. The average humidity is relatively high (the mean annual value is about 78) the dry season being short or moderated by proximity to the sea.

Rainfall (millimetres)

Northern Tropical Semi-evergreen Forest.

Month	Assam DHUBRI 35 m.	Assam TEZPUR 79 m.	Assam SIL-CHAR 29 m.	West Bengal JALPAI-GURI 83 m.
January	8	15	20	8
February	19	25	48	17
March	42	49	172	32
April	138	153	385	98
May	401	271	417	300
June	612	308	589	659
July	437	348	521	818
August	338	331	515	641
September	356	210	389	539
October	125	104	184	141
November	10	23	45	12
December	2	6	11	
Total for year (M.A.R.)	2,487	1,845	3,294	3,267
No. of rainy days	95	105	137	108
No. of months with less than 50 mm.	5	5	4	5
M. A. Humidity	76	78	78	75
No. of years	60	40	60	55

Topography.—Largely on flat ground but also in hilly country in Assam and Orissa.

Rock and Soil.—Most of the area covered by the type is alluvial, but part is on Bengal gneiss and other crystalline and metamorphic rocks. The soil may be sandy loam on heavy alluvium or clayey soil *in situ* : it is usually yellow or red but black richly humic soils are encountered in North Bengal.

5. GENERAL FLORISTICS

The top storey may include a few *Dipterocarpus* but their presence is usually an indication either that the forest is a retrogression stage from the tropical evergreen type or a preclimax stage to it. *Syzygium*, *Cinnamomum*, *Magnoliaceae* and *Artocarpus*, all typical evergreen genera, commonly contribute, whilst *Terminalia* spp. (*T. myriocarpa*, *T. citrina*, *T. tomentosa*), *Tetrameles* and *Stereospermum* are common among the deciduous trees. The species are usually intimately mixed but small consociations of dominants are frequent. *Shorea robusta* only retains a footing with burning or other desiccating factors but at present occupies a good deal of territory as a stable subclimax with burning and would otherwise be rapidly replaced owing to failure to regenerate.

The underwood consists of various *Lauraceae* (*Phoebe*, *Machilus*, *Actinodaphne*, etc.), *Anonaceae* (*Polyalthia*), *Meliaceae* (*Aphanamixis*), *Mesua*.

Bambusa arundinacea, *Dendrocalamus hamiltonii*, *Melocanna bambusoides* are the most characteristics bamboos.

The ground flora is poor where the underwood is dense, but evergreen *Rubiaceae* and monocotyledonous herbs (*Alpinia*, etc.) are abundant where the light is adequate; grass replaces these evergreens under burning but is practically absent otherwise.

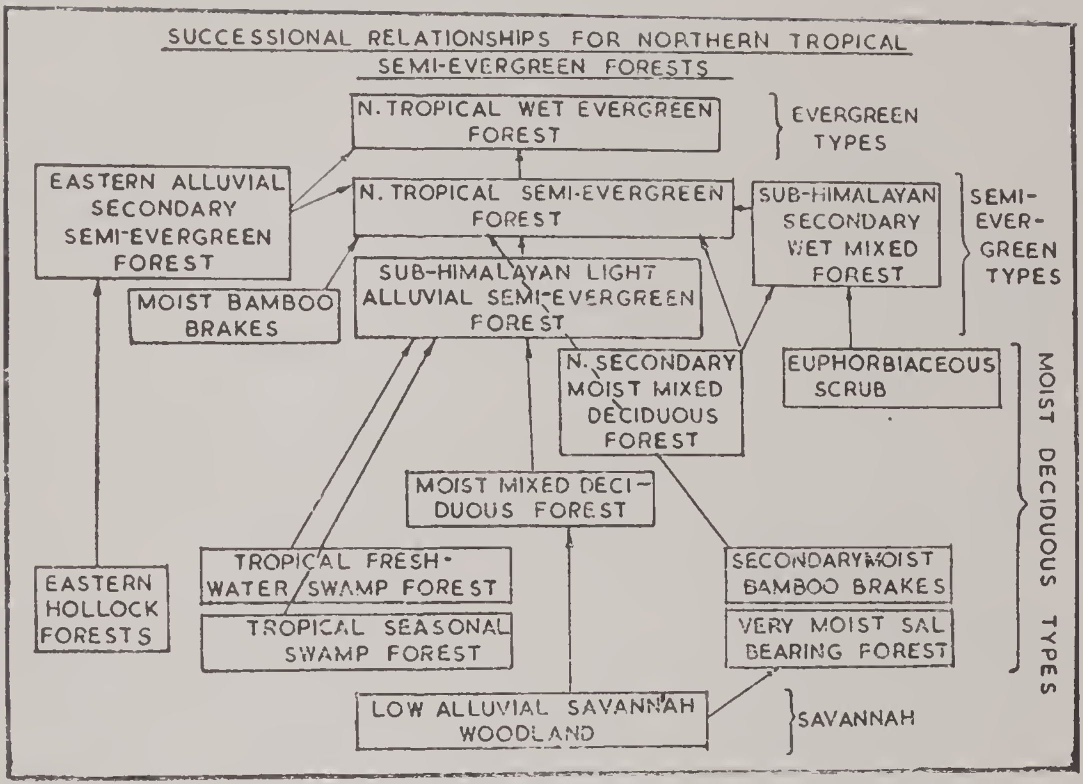
6. SUBDIVISIONS, SUCCESSIONS, etc.

As for the northern tropical evergreen forest, so also for the semi-evergreen, subdivision on a geographical basis seems indicated and four forms are distinguished, three from the Assam-Bengal region, and one on the east coast. Cane brakes (E1, p. 101) are of common occurrence and moist bamboo brakes (E3, p. 101) likewise.

The primary seres on new river deposits, both fresh water and tidal, are as for evergreen except for the last stage. The secondary are seres similarly indistinguishable, but sub-himalayan wet mixed forest (C1/2S3, p. 98) calls for attention though it is not yet proved what is the corresponding climax type or types. Deciduous savannah forest (3C/C2/DS1, p. 146) readily develops on alluvial soil after clearing or appreciable opening up, grass growth and fire being the immediate causes. Into these savannahs sal, which is characteristic of the moist deciduous forests, spreads in time and with protection may come up as a nearly pure crop, to be displaced in time by the wet mixed type.

The following types are described below :—

C1 *Assam Valley semi-evergreen forest*
1a *Assam alluvial plains semi-evergreen forest*
1b *Eastern submontane semi-evergreen forest*
1S1 *Sub-Himalayan light alluvial semi-evergreen forest*
1S2 (*Syzygium parkland*)
2S1 (*Pioneer Euphorbiaceous scrub*)
2S2 *Eastern alluvial secondary semi-evergreen forest.*
2S3 *Sub-Himalayan secondary wet mixed forest*
C2 *Cachar semi-evergreen forest*
C3 *Orissa semi-evergreen forest*


SUCCESSIONAL RELATIONSHIPS FOR NORTHERN TROPICAL SEMI-EVERGREEN FORESTS
N. TROPICAL WET EVERGREEN FOREST
EVERGREEN TYPES
EASTERN ALLUVIAL SECONDARY SEMI-EVERGREEN FOREST
N. TROPICAL SEMI-EVERGREEN FOREST
SUB-HIMALAYAN SECONDARY WET MIXED FOREST
SEMI-EVER-GREEN TYPES
MOIST BAMBOO BRAKES
SUB-HIMALAYAN LIGHT ALLUVIAL SEMI-EVERGREEN FOREST
N. SECONDARY MOIST MIXED DECIDUOUS FOREST
EUPHORBIACEOUS SCRUB
MOIST DECIDUOUS TYPES
MOIST MIXED DECIDUOUS FOREST
EASTERN HOLLOCK FORESTS
TROPICAL FRESH-WATER SWAMP FOREST
TROPICAL SEASONAL SWAMP FOREST
SECONDARY MOIST BAMBOO BRAKES
VERY MOIST SAL BEARING FOREST
LOW ALLUVIAL SAVANNAH WOODLAND
SAVANNAH

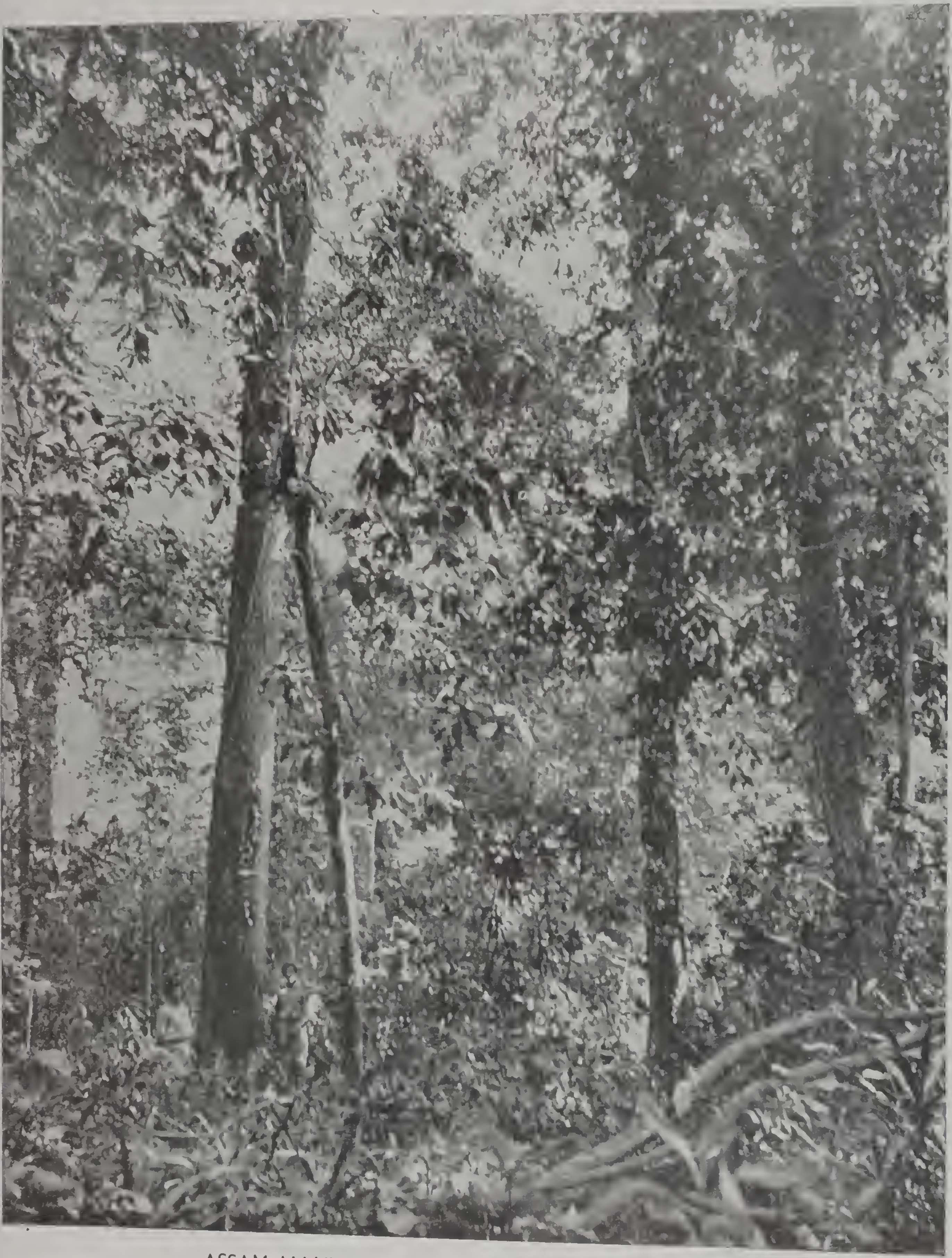
C1. Assam Valley Tropical semi-evergreen forests.
C1a. Assam alluvial Plains semi-evergreen forests.

NOMENCLATURE.—

General	(U. Assam tropical semi-evergreen) (Sub-Himalayan tropical semi-evergreen)—(CHAMPION) (1936).
West Bengal	*Eugenia-Phoebe* association—(COWAN).
Assam	*Altingia-Magnolia-Cinnamomum* association—(ROWBOTHAM). Assam Valley semi-evergreen formation—(RAJKHOWA). *Laurus-Melia hylium*—(BOR). *Cinnamomum-Amoora* association—(ROWNTREE). Mixed evergreen forests—(WORKING PLANS). *Mesua*—Other species post-climax—(BOR).

DESCRIPTION.—A closed largely evergreen high forest including a varying proportion of deciduous trees mainly as a broken top storey. Less uniform and imposing than the tropical evergreen forest but still including fine, tall and large trees. Middle storey dense and varied undergrowth including much cane, etc. Buttresses are a common feature and strangling figs are numerous.

DISTRIBUTION.—In the heavy rainfall tract of N. Bengal and the adjoining parts of Assam and Bhutan, at present often confined to the vicinity of *tarai* streams and occupying only a limited area.



ASSAM ALLUVIAL PLAINS SEMI-EVERGREEN FOREST
Phoebe-Amoora association. Goalpara East Division, Assam.

S. K. Seth

ILLUSTRATION.—Plate 12.

LOCALITY FACTORS.—Occurs under a wide range of rainfall from 1,500 mm. to 5,000 mm. or more, with the number of rainy days varying from 90 to 175, low figures usually being compensated by other favourable factors. Typical rainfall data are given for Sam Singh T.E. on page 74 and the temperatures are probably much as given for Sibsagar; mostly on light alluvial soils.

FLORISTICS.—

(i) *Kalimpong division, W. Bengal* (COWAN)—

I. *Eugenia formosa**, *Phoebe hainesiana**, *P. attenuata*, *Beilschmiedia* spp.*, *Dysoxylum* spp., *Eugenia ramosissima*, *Castanopsis indica*, *C. tribuloides*, *Litsea* spp., *Terminalia myriocarpa*, *Michelia champaca*, *Cinnamomum* spp., *Elaeocarpus* spp., *Tetrameles nudiflora*, *Ailanthus grandis*, *Talauma hodgsoni*, *Mangifera indica*, *Canarium sikkimense*.

II. *Meliosma simplicifolia*, *Amoora wallichii*, *Gynocardia odorata*, *Turpinia pomifera*, *Styrax* sp., *Actinodaphne obovata*, etc.

IIa. No bamboos.

III. Evergreen shrubs including many *Rubiaceae*.

V. Numerous climbers.

NOTE.—It is possible that this should only be considered as an edaphic postclimax on permanently moist soils but it is included here as it is by no means improbable that it represents the climatic climax over a much larger tract including much that is now under the admittedly seral wet mixed type 2S3 described on p. 98; the latter type merges into this, rendering recognition difficult at times.

(ii) *Aka Hills, Assam.*—

(a) *Laurus-Melia hylium* (BOR).

I. *Phoebe* spp*., *Beilschmiedia* spp., *Cinnamomum cecidodaphne*, *Machilus ramosa*, *Alseodaphne*, *Amoora* spp.*, *Dysoxylum* spp., *Cedrela* spp., *Canarium*, *Michelia*, *Manglietia*, *Castanopsis*, *Ailanthus grandis*, *Tetrameles*, *Altingia*.

II. *Quercus* spp., *Litsea* spp., *Vatica*, *Talauma*, *Meliosma*, *Artocarpus*, etc.

III. *Strobilanthes* spp., *Psychotria* spp., *Laportea*, *Pinanga*.

V. *Calamus* spp.

(b) *Mesua-other species post-climax* (BOR).

BOR differentiates this sub-type occurring with the main type on deep porous soils with high rainfall and humidity. The species present are mostly the same but *Mesua* is conspicuously abundant even up to 80% of the crop. *Quercus lamellosa* and *Michelia doltsopa* typical of high zones in the hills are frequent. Among the few deciduous trees are *Tetrameles* and *Echinocarpus*. Most of the trees are buttressed. Creepers are rare. *Dendrocalamus hamiltonii* and *Pseudostachyum polymorphum* are very common.

(iii) *Preservation Plot No.* 1, *Khumani, Kalimpong Division, W. Bengal*.—

I. *Mesua ferrea** 75%, *Phoebe attenuata**, *Syzygium* spp., *Dysoxylum* spp., *Mangifera sylvatica, Cinnamomum obtusifolium, Litsea* spp., *Eugenia formosa*.

II. *Meliosma simplicifolia, Amoora wallichii, Talauma hodgsoni*.

(iv) *Brahmaputra Valley, Assam*.—

Cinnamomum-Amoora association (ROWNTREE)

I. *Phoebe* spp., *Beilschmiedia* spp., *Cinnamomum* spp*., *Amoora wallichii**, *Dysoxylum* spp., *Chukrasia, Canarium, Syzygium* spp., *Castanopsis* spp., *Manglietia, Michelia, Ailanthus grandis, Tetrameles, Michelia champaca*.

II. *Litsea, Vatica, Talauma, Meliosma, Quercus* spp.

IIa. *Bambusa pallida, Dendrocalamus hamiltonii*.

V. *Calamus* spp., *Dalbergia, Porana, Vitis*.

(v) *S. bank of Brahmaputra, Assam* (RAJKHOWA)—

I/II. *Artocarpus chaplasha* (1-2%), *Alphonsea ventricosa* (0-5%), *Castanopsis indica** (4-7%), *Canarium* spp. (1-5%), *Dillenia indica* (0-6%), *Dysoxylum procerum** (2-4%), *Magnolia* spp. (1-10%), *Mesua* (0-7%), *Stereospermum personatum* (7-8%), *Tetrameles* (0-6%).

(vi) *N. bank of Brahmaputra, Assam* (RAJKHOWA)—

I/II. *Artocarpus chaplasha* (1%), *Amoora wallichii** (1-6%), *Castanopsis* spp. (2-3%), *Canarium* spp. (2%), *Dysoxylum procerum** (5-8%), *Dillenia indica* (0-11%), *Syzygium* spp. (1-2%), *Mesua* (1-3%), *Garuga pinnata* (2-5%), *Michelia montana* (1-5%), *Manglietia insignis* (3-5%), *Pterospermum* (0-5%), *Machilus globosa* (1-3%), *Phoebe goalparensis* (6-13%), *Talauma* (2-8%), *Taraktogenos* (1-2%).

C1b. Eastern submontane semi-evergreen forest

NOMENCLATURE.—*Schima-Bauhinia association* (COWAN).

DESCRIPTION.—Closed but rather irregular high forest with evergreen species predominating in the top canopy, but with a number of deciduous or nearly deciduous species; the lower canopy is mainly evergreen and without bamboos and there is usually a shrubby undergrowth.

DISTRIBUTION.—In the sub-Himalayan tract and the lower slopes of the hills between the mainly deciduous and mainly evergreen forests, in N. Bengal and adjoining parts of Assam and Nepal.

LOCALITY FACTORS.—The type is associated with a heavy rainfall of even upto 5,000 mm. but usually occurs on well drained slopes from the foot of the range to about 760 m. or more.

FLORISTICS.—

(i) *Lower hill slopes, Kalimpong Division, W. Bengal* (COWAN).—

(*Schima-Bauhinia* association).

I. *Schima wallichii** (E)(19%), *Bauhinia purpurea** (E/D) 10%, *Cedrela toona* (D) 3%, *Stereospermum tetragonum* (D) 3%, *Castanopsis indica* (E), *Ailanthus grandis* (D), *Duabanga grandiflora* (E), *Eugenia formosa* (E), *Dysoxylum* spp. (E), *Michelia champaca* (E), *Tetrameles nudiflora* (D), *Gmelina arborea* (D).

II. *Phoebe lanceolata**(4%), *Turpinia pomifera, Garcinia stipulata, Meliosma simplicifolia, Actinodaphne obovata, Mallotus* spp., *Gynocardia odorata.*

IIa. *Dendrocalamus hamiltonii*, or none.

(ii) *E. Nar block, Kalimpong Division, W. Bengal.*—

I. As for (i) with the addition of *Terminalia myriocarpa, Amoora wallichii, Canarium sikkimense* and *Acrocarpus.*

NOTE.—The wet mixed forest dealt with below on p. 98 is unquestionably a seral community, but it is not at present possible to say definitely what the climax of the sere is. On indirect evidence it should mostly be the northern tropical wet evergreen, but it is equally probable that there are considerable tracts which would come under the present type, both in tracts where the rainfall is less heavy and others on light or well drained soils with heavy rainfall. Similarly semi-evergreen forest may be found on free draining sites adjoining evergreen forest on the more retentive soils.

1S1. Sub-Himalayan light alluvial semi-evergreen forest

(a) *Sadiya district, Doyang and Dhansiri valleys of Sibsagar district, Assam.*—
Terminalia-Phoebe associes (ROWNTREE).

I. *Terminalia myriocarpa*, Phoebe cooperiana** (Sadiya) or *P. cooperiana** (Sibsagar), *Ailanthus grandis, Tetrameles nudiflora, Bischofia, Sloanea assamica, Duabanga.*

II. *Mesua ferrea, Dillenia indica, Meliosma, Gynocardia, Amoora.*

IIa. *Bambusa pallida, Pseudostachyum polymorphum.*

III. *Calamus* spp., *Litsea* sp., *Pinanga, Musa, Dracaena, Clerodendron nutans.*

IVa. *Alpinia, Phrynium, Clinogyne.*

V. *Calamus* spp., *Vitis* spp., *Entada, Derris,* etc.

NOTE.—ROWNTREE considers this an advanced stage in a succession which in part at least must be considered secondary as the area was densely populated prior to 150 years ago.

(b) *Goalpara West Division, Assam.*—

Syzygium-Tetrameles-Machilus subtype (RAJKHOWA).

I. *Syzygium* (*Eugenia*) spp.* (25%), *Tetrameles** (17%), *Machilus bombycina** (15%), *Stereospermum personatum* (4%), *Albizzia lebbek* (3%), *Garuga* (2%).

II. *Amoora wallichii* (5%), *Premna bengalensis* (3%), *Sapium baccatum* (2%).

(c) *Goalpara West Division, Assam.*—

Michelia subtype (RAJKHOWA).

I. *Michelia champaca** (6%), *Tetrameles* (10%), *Stereospermum* (9%), *Schima wallichii* (6%), *Pterygota alata* (3%), *Machilus bombycina* (8%).

II. *Amoora wallichii* (7%), *Castanopsis* spp. (5%), *Syzygium* spp. (9%), *Premna bengalensis* (4%).

1S2. Syzygium parkland

NOMENCLATURE.—*Syzygium* parkland (BOR).
High savannah (ROWNTREE).

DESCRIPTION.—A very open stand of low branchy trees about 3 m. high growing in a sea of grass 2 m. or more high.

DISTRIBUTION.—On heavy alluvium adjoining sal forests in the Brahmaputra valley.

LOCALITY FACTORS.—Soil heavy and waterlogged during the rains. Burnt annually in the hot weather.

FLORISTICS. (BOR)—

I. *Syzygium cerasoideum**, *S. cumini**, *Emblica officinalis*, *Gmelina arborea*, *Semecarpus anacardium*, *Bridelia* spp.

III. *Glochidion assamicum*, *Leea edgeworthii*, *Antidesma diandrum*.

IVb. *Imperata* (dominant), *Saccharum spontaneum*, *Ophiuros*, *Vetiveria* etc.

NOTE.—"One of the stages in the succession from grassland to high forest" (BOR). The type appears to be intermediate between the wetter 4/2S2 and better drained 4/2S1 in which tall trees such as *Salmalia* and *Albizzia* replace the low *Syzygium*.

2S1. (Pioneer Euphorbiaceous Scrub)

This is described under group 1/2S1, p. 80.

2S2. Eastern alluvial secondary semi-evergreen forest

NOMENCLATURE.—Assam secondary semi-evergreen formation. (RAJKHOWA).
Stereospermum-Ailanthus-Albizzia associes. (ROWNTREE)

DESCRIPTION.—High forest of mixed species similar to the climax type with the inclusion of more deciduous species.

DISTRIBUTION.—Plains of U. Assam typified by Hollongapar Reserve, Sibsagar Division, Assam.

LOCALITY FACTORS.—The climate of Golaghat and Tezpur may be taken as representative, rainfall being in the neighbourhood of 2,000 mm. but similar forest occurs with considerably greater precipitation. Alluvial loamy soils in the plains.

FLORISTICS.—

(i) *Hollongapar Reserve, Sibsagar Division, Assam* (ROWBOTHAM)—

I. *Tetrameles nudiflora* (D), *Stereospermum personatum* (D), *Terminalia myriocarpa* (D), *T. citrina* (D), *Dipterocarpus pilosus* (E), *Artocarpus chaplasha* (E), *Castanopsis hystrix* (E), *Aquilaria agallocha* (E).

II. *Macaranga* spp. (E), *Melia azedarach* (D), *Mesua ferrea* (E), *Amoora wallichi* (E), *Vatica lanceaefolia* (E).

IIa. *Pseudostachyum polymorphum.*

NOTE.—The tract is believed to have been jhumed over 100 years ago; the evergreens are becoming dominant in places and appear likely to spread further.

(ii) *Lakhimpur, Assam, Open type hollong forest.* (PURKAYASTHA)—

I. *Ailanthus grandis**, *Pterospermum*, *Albizzia lucida*, *Stereospermum**, *Terminalia citrina*, *T. bellerica*, *Dipterocarpus macrocarpus*, *Anthocephalus.*

II. *Macaranga*, *Mallotus albus*, *Zanthozylum*, *Alstonia*, *Actinodaphne*, *Litsea monopetala*, etc.

IIa. *Bambusa pallida*, *Pseudostachyum*, *Dendrocalamus hamiltonii.*

III. *Laportea*, *Melastoma*, *Osbeckia.*

IVa. *Phrynium*, *Alpinia.*

V. *Calamus* spp.

NOTE.—A stage of a secondary sere, returning to the evergreen Dipterocarp type.

(iii) *Naduar Reserve, Assam* (RAJKHOWA)—

I. *Pterospermum acerifolium**(8%), *Dillenia indica** (25%), *Dysoxylum procerum* (6%), *Salmalia malabarica* (4%), *Bischofia* (2%), *Artocarpus chaplasha* (2%), *Duabanga* (2%), *Litsea sebifera* (2%).

II. *Premna latifolia* (8%), *Bauhinia* sp. (6%).

NOTE.—The forest was originally described as a swamp type.

(iv) *Assam. Tetrameles-Stereospermum-Cedrela* formation (ROWNTREE)—

I. *Tetrameles**, *Stereospermum**, *Cedrela toona**, *Albizzia procera*, *Alstonia* (E), *Amoora wallichii* (E), *Artocarpus chaplasha* (D), *Pterygota alata* (E/D), *Euphoria longana* (E), etc.

II. *Hydnocarpus kurzii* (E), *Amoora* spp. (E), *Drypetes elliptica* (E), *Macaranga*, *Dysoxylum procerum* (E), etc.

V. *Spatholobus*, *Derris*, *Combretum decandrum*, *Acacia pruinescens* etc.

NOTE.—ROWNTREE treats this type as a deciduous climax formation but from his description it appears definitely to be an extensive secondary type following clearing and fire. Later workers have queried whether this type is correctly interpreted.

(v) *Assam. Pterospermum-Ailanthus-Albizzia* associes (ROWNTREE).

NOTE.—ROWNTREE describes under this title three "open types" of forest thought to be more or less advanced stages of secondary seres following shifting cultivation in the climax evergreen forest. In two of them, *Terminalia myriocarpa* is well represented giving a similar appearance to the primary seral types 1S1 described above, probably leading to the 1B/C2 climax (p. 77) whilst the third is probably similarly related to the *Dipterocarpus* 1B/C1 (p. 76). Floristic lists are given by ROWNTREE.

2S3. Sub-Himalayan secondary wet mixed forest

NOMENCLATURE.—The term "wet mixed" is well established in Bengal.

DESCRIPTION.—A dense evergreen forest with or without scattered tall deciduous or evergreen trees standing above the general canopy. Consociations are fairly frequently found but the crop is typically very mixed. Bamboo is usually absent and as usual the amount of undergrowth varies from almost *nil* to a dense evergreen ground cover. Climbers are not usually heavy apart from the cane brakes which are frequently encountered particularly on the wettest ground.

DISTRIBUTION.—In the heavy rainfall tract of N. Bengal and the adjoining parts of E. Assam and Bhutan, at present confined to the moister soils of the *tarai* belt and lower parts of the *bhabar* but rapidly extending with protection.

LOCALITY FACTORS.—Rainfall is usually over 2,500 mm. and the effect of the well marked dry season (4 months) is largely counter-acted by the moisture of the soil which is maintained from underground sources. Kalchini is a representative locality Kochugaon in Goalpara, Assam, with 4,000 mm. rainfall is very similar. The cold weather is also pronounced and with heavy dew but there is no frost. The soil is alluvium of varying consistence but mostly heavy and moisture retaining.

ILLUSTRATION.—Plate 13.

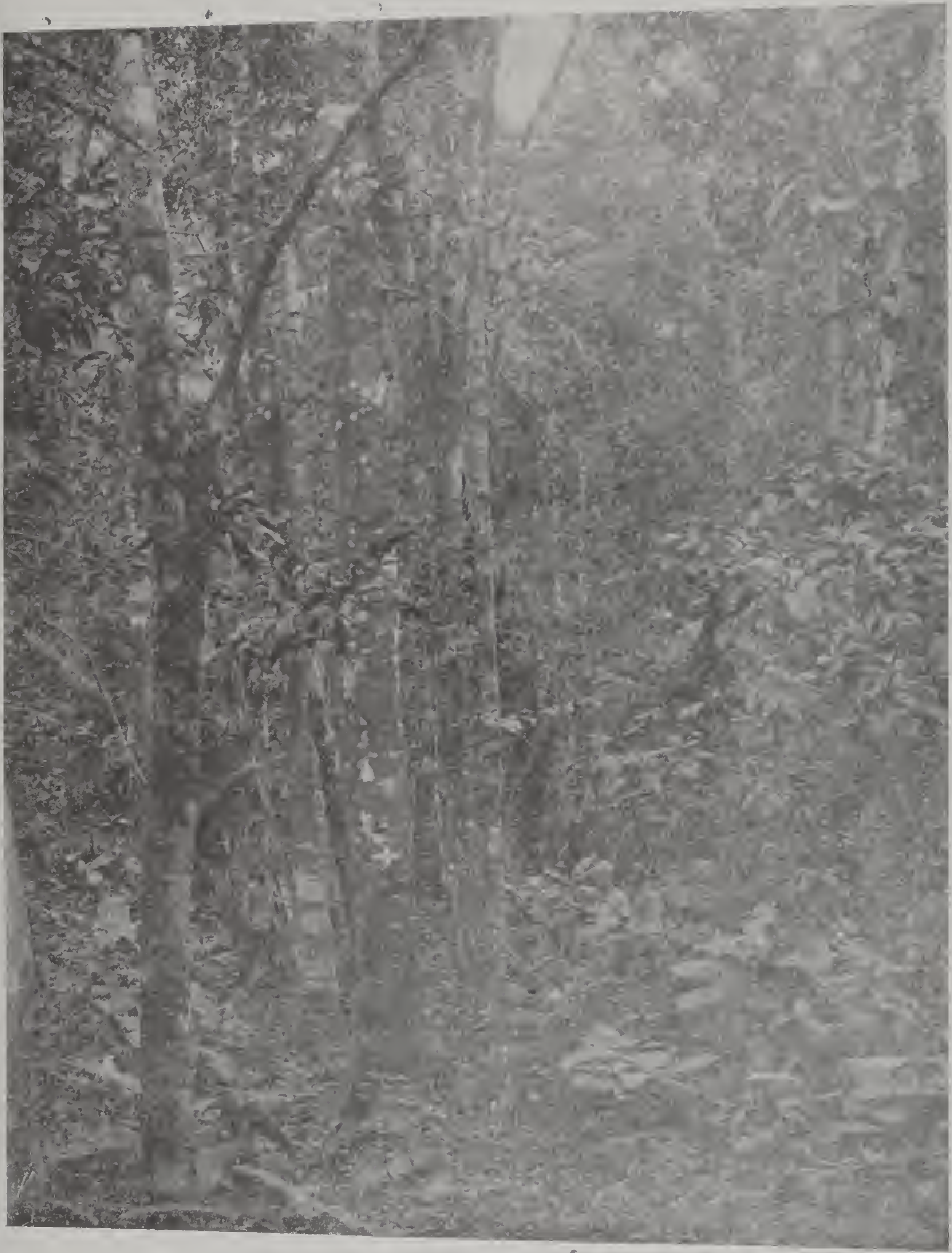
FLORISTICS.—

(i) *Preservation Plot No. 2, Lataguri, Jalpaiguri, W. Bengal (including part of Linear S. P. 4)*.—

I. *Michelia montana**, *Turpinia pomifera*, *Eugenia praecox**, *Machilus* spp., *Elaeocarpus* spp., *Echinocarpus sterculiaceus*, *Quercus* sp., *Castanopsis* sp., *Pygeum acuminatum*, *Shorea robusta*, *Myristica* sp.*

II. *Saurauja roxburghii*, *Aporosa dioica*, *Symplocos* sp., *Meliosma pinnata*, *Styrax serrulatum*, *Aphanamixis polystachya* (*Amoora rohituka*), *Cryptocarya floribunda*, *Litsea* spp., *Dysoxylum binectariferum*, *Casearia* sp.

III. Sparse *Leea crispa*; various monocotyledons.



SUB-HIMALAYAN SECONDARY WET MIXED FOREST
Ilex godajam (left centre), *Ternstroemia japonica* (+ mark), *Machilus gamblei*, *M. villosa*, *Talauma hodgsoni*, *Eurya acuminata*, *Actinodaphne angustifolia* etc.
Bendubi, Kurseong Division, West Bengal.

H. G. Champion

FRI&C/64]

IV. Climbers moderate to heavy including canes.

(ii) *Preservation Plot No.* 23, *Bengdubi, Kurseong division, W. Bengal.—*

I. *Schima wallichii, Machilus villosa, Syzygium cumini, Ternstroemia gymnanthera, Podocarpus neriifolia, Lophopetalum fimbriatum, Michelia oblonga, M. champaca*, Ailanthus grandis, Turpinia pomifera*, Elaeocarpus varunnia, Actinodaphne obovata, Pterygota alata, Shorea robusta.*

II. *Ilex godajam, Aporosa dioica, Acronychia pedunculata, Aphanamixis polystachya, Magnolia pterocarpa, Mastixia pentandra, Eurya acuminata, Sapium baccatum, Meliosma simplicifolia, Oroxylum indicum, Mallotus philippensis, Diplospora singularis, Casearia vareca, Macaranga denticulata, Careya arborea, Saurauja roxburghii*, etc.

III. *Coffea bengalensis, Clerodendrum viscosum.*

IV. Ferns etc.

V. *Piper* spp., canes.

(iii) *Western portion of Preservation Plot No.* 6, *Bania Block, Cooch Behar division, W. Bengal.—*

Resembles (ii) in having *Michelia champaca* and *Artocarpus*, but lacks *Schima* and *Dysoxylum*. It also includes *Myristica longifolia, Tetrameles, Polyalthia simiarum* and *Mesua ferrea*. It is of interest that the *Myristica* and *Polyalthia* are regenerating freely, as also is *Mesua* which is spreading from trees which may have been introduced.

General Note.—It is quite clear that this type covers stages of the succession to a north tropical evergreen forest from the deciduous forest which has displaced the latter owing to human activities among which clearing must have played some part, but burning out from the clearings may in the long run have been most influential. The finest development is that including *Michelia champaca*. It is not possible to determine whether any representative examples of the climax still exist, for the type described above as Upper Assam valley tropical evergreen has almost certainly been considerably influenced by the same human activities.

C2. Cachar tropical semi-evergreen forest

NOMENCLATURE.—

Assam.—Mixed semi-deciduous type (in part) (W.P.).

Manipur.—Tectona-Dipterocarpus hylium (in part) (DEB).

DESCRIPTION.—The upper canopy is 18-24 m. usually not dense, though almost closed on tops and ridges of hills. Elsewhere reduced to a very few trees scattered over dense *Melocanna*. There is no sharp line of demarcation between this and the moist deciduous forest.

DISTRIBUTION.—On the lower slopes of the Cachar hills and in the Surma Valley, the Lushai and Manipur hills.

LOCALITY FACTORS.—The climatic data for Silchar may be taken as fairly typical with a rainfall somewhat over 2,500 mm. Southern and western aspects are favoured, the moister northern and eastern slopes being in possession of the tropical evergreen. The rainfall for the Manipur type is estimated at 2,000 mm. at an altitude of 100 m. The soil is sandy loam, and laterite at the foot hills.

FLORISTICS.—

(i) *Cachar, Assam.*—

I & II. *Artocarpus chaplasha**, *Dipterocarpus turbinatus**, *Palaquium polyanthum, Cynometra polyandra, Eugenia* spp., *Vitex peduncularis, Ptereospermum acerifolium, Pterygota alata, Chukrasia velutina, Tetrameles nudiflora, Adina cordifolia, Protium serratum, Albizzia procera, Premna bengalensis, Gmelina arborea, Salmalia insignis, Stereospermum personatum* and many others.

IIa. *Melocanna bambusoides.*

III. Evergreen shrubs.

(ii) *Kabaw Valley, Manipur.* 100 m. (DEB).—

I. *Dipterocarpus tuberculatus** (f), *D. turbinatus** (f), *Melanorrhoea usitata** (f), *Duabanga grandiflora* (o), *Xylia dolabriformis* (o), *Dillenia pentagyna* (o), *Lagerstroemia parviflora* (o), *Terminalia tomentosa* (o), *Gmelina arborea* (o).

II. *Terminalia citrina, Emblica officinalis, Engelhardtia spicata, Saurauja nepaulensis, Symplocos racemosa, Mallotus philippensis.*

IIa. *Melocanna bambusoides.*

III. *Wendlandia grandis, Woodfordia fruticosa, Buddleia asiatica, Indigofera pulchella, Leea* spp., *Desmodium* spp., *Licuala peltata.*

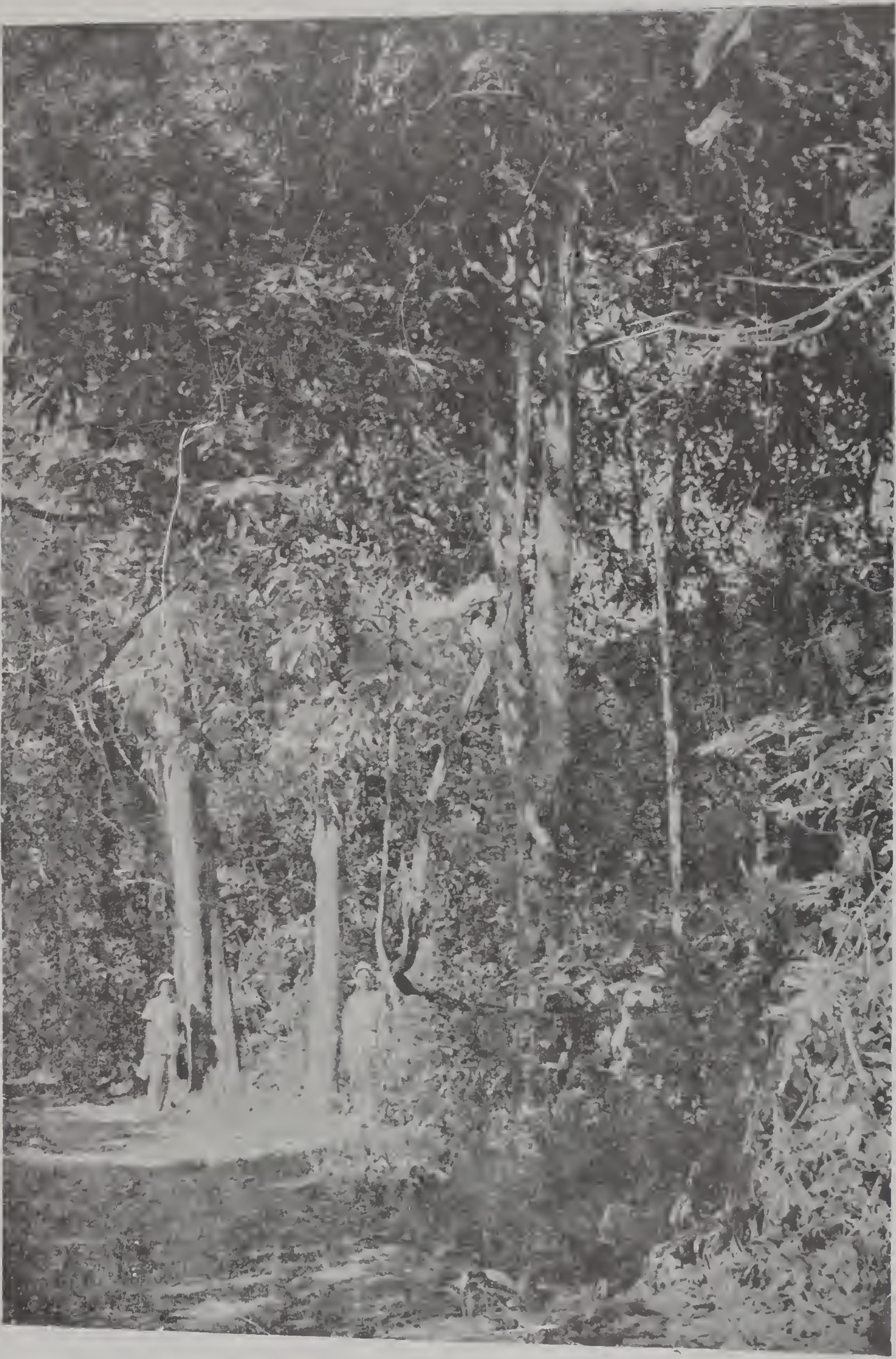
IVa. *Polygala crotolarioides, Polygonum chinense, Hedychium villosum.*

V. Climbers sometimes dense, *Entada phaseoloides, Mucuna bracteata, Atylosia crassa* etc.

NOTE.—Here also further studies are badly needed. Though much of the area would be expected to have tropical evergreen as the climatic climax, it seems likely that the semi-evergreen stage holds this position locally at least on the more exposed aspects. A great deal of the area has been traversed by jhuming and has degenerated into bamboos brake with *Melocanna bambusoides, Tinostachyum dullooa* and *Bambusa balcooa* with scattered standards both evergreen and deciduous.

C3. Orissa tropical semi-evergreen forest

DESCRIPTION.—Whilst a number of the top storey trees are deciduous, they are leafless for a short time only and not simultaneously, and the second storey is entirely evergreen.



CRISSA SEMI-EVERGREEN FOREST

The biggest stem is *Firmiana colorate*. Mango is also common. Puri Division, Orissa.

S. K. Seth

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DISTRIBUTION.—On the Orissa hills at 800 m. or so and in lower permanently moist valleys.

LOCALITY FACTORS.—Limited to fertile fresh soils; rainfall 1,500 mm. or more. Humidity high under oceanic influence.

ILLUSTRATION.—Plate 14.

FLORISTICS.—

I. *Artocarpus lakoocha** (D), *Michelia champaca* (E), *Celtis tetrandra* (D), *Bridelia tomentosa* (D), *B. verrucosa* (D), *Dillenia pentagyna* (D), *Saraca indica* (E), *Ficus* spp., *Mangifera indica**, *Firmiana colorata.**

II. *Aphanamixis polystachya*, *Mesua ferrea*, *Phoebe lanceolata*, *Polyalthia* spp., *Macaranga peltata*, *Glochidion* spp., *Litsea nitida*, etc.

III/IVa. Many small evergreen shrubs and perennials; *Curcuma aromatica*, *Leea crispa.*

NOTE.—The undisturbed climatic climax no longer exists and we can only surmise that the rapid invasion of the damp deciduous forests and coastal sal by evergreen species after successful fire protection will lead to a climax which would be classified here, in fact some existing patches of forest appearing to be post climaxes on favoured sites might even be included as tropical fully evergreen forest, where also it has been much planted outside its natural range.

GENERAL EDAPHIC AND SERAL TYPES OF SEMI-EVERGREEN FORESTS

E1. (Cane brakes)

This is described under group 1/E1, p. 79.

E2. (Wet bamboo brakes)

This is described under group 1/E2, p. 80.

E3. Moist bamboo brakes

DESCRIPTION.—More or less continuous cover of one or two species of tall clumped bamboos with occasional standards of *Terminalias* and other trees.

DISTRIBUTION.—Locally throughout the semi-evergreen and moist deciduous types.

LOCALITY FACTORS.—The natural occurrence of bamboo brakes would appear to depend on soil conditions, and they favour stream sides and shady slopes, but they have extended their territory very greatly as secondary associations.

ILLUSTRATION.—Cf. Plate 7.

FLORISTICS.—

(i) *Andaman Islands* (WORKING PLAN)—

I. *Terminalia** spp., *Salmalia*, etc.

II. *Oxytenanthera** sp., *Bambusa schizostachyoides.*

(ii) *Nilambur, Kerala.*—

I. *Terminalia crenulata.**

IIa. *Bambusa arundinacea.**

III. *Clerodendrum viscosum.**

NOTE—The thorny bamboo, *Bambusa arundinacea,* is met with along streams throughout tropical India and often extends some distance up the slopes in sheltered localities (Kanara and Nilambur provide good examples). As it reaches maturity it forms giant clumps (upto 20 m. high) standing well apart on the ground which carries very little else except a few small shrubs. This thorny bamboo brake extends practically unchanged northwards into the northern moist deciduous forests, where also it has been much planted outside its natural range.

E4. Lateritic semi-evergreen forest

NOMENCLATURE.—

Mysore—*Xylia* mixed forest (DAVIS).

DISTRIBUTION.—Occurs on lateritic soils in various parts of India particularly in the peninsular region extending upto S. Bengal and is particularly characterised by the presence of *Xylia xylocarpa.*

LOCALITY FACTORS.—The climate is as for the main types but the soil is usually derived from thick lateritic and is shallow and dry.

FLORISTICS.—

I. *Xylia xylocarpa** (va), *Pterocarpus marsupium** (f), *Anogeissus latifolia* (o), *Grewia tiliaefolia* (o), *Terminalia* spp.* (f).

II. *Careya arborea, Bridelia retusa, Calycopteris floribunda, Strychnos nux-vomica, Leea indica.*

III. Generally sparse—*Adhatoda vasica, Holarrhena antidysenterica.*

2S1. Secondary moist bamboo brakes

DESCRIPTION.—The thorny bamboo brake is identical in form throughout both northern and southern moist deciduous forests. It is sufficiently aggressive to be able to hold its own against tree growth though the latter probably gains ground after seed years, so that very gradually the bamboo ceases to dominate. The brakes of N. Bengal and Assam, which are formed by *Dendrocalamus hamiltonii* with its characteristic low spreading habit, also holds tenaciously to ground once occupied. Under a closed bamboo crop the floor is usually almost devoid of tree regeneration but scattered shrubs and thin grass may occur.

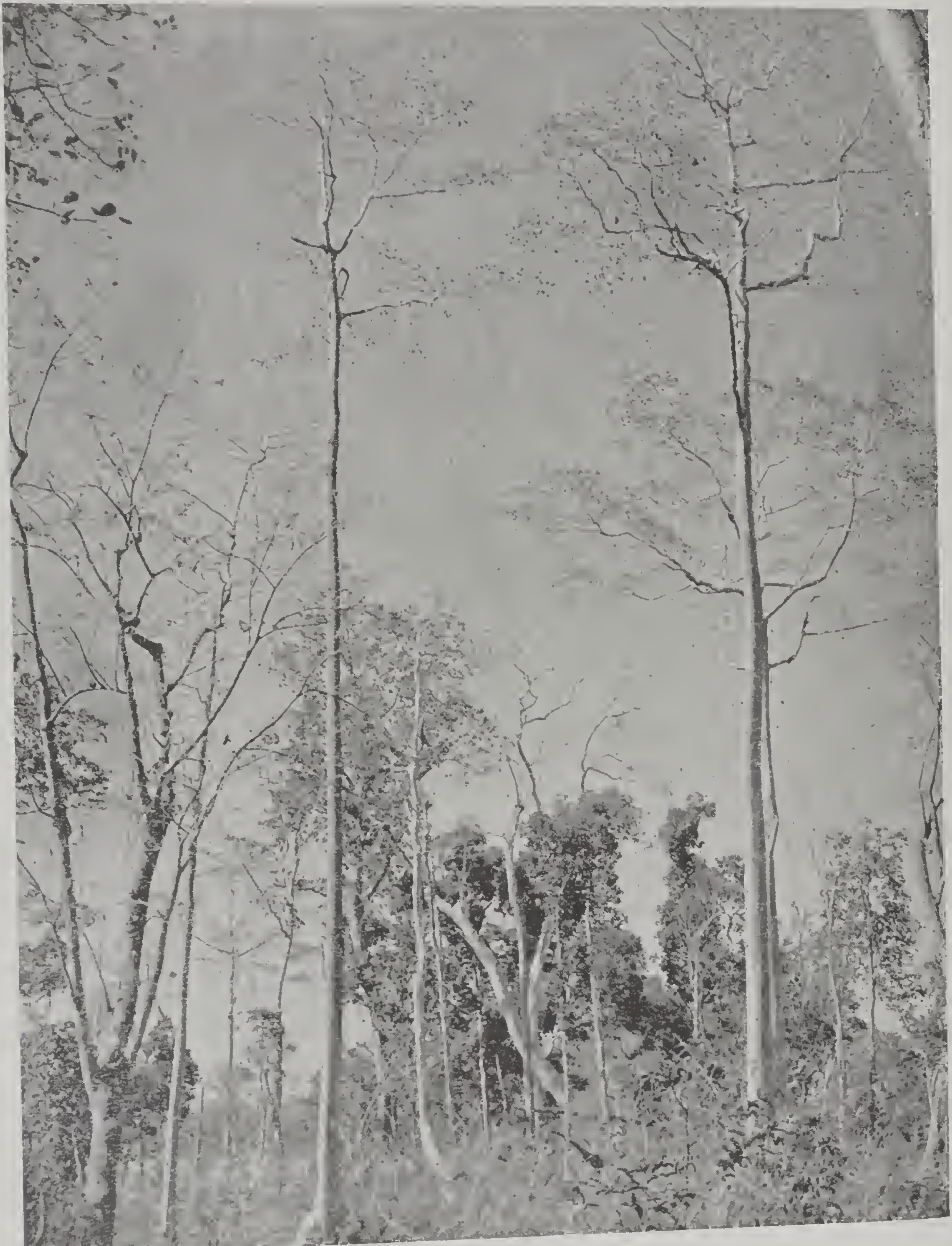
DISTRIBUTION.—Locally throughout the moist deciduous forests.

LOCALITY FACTORS.— As per the main type.

ANDAMANS MOIST DECIDUOUS FOREST

Large *Pterocarpus dalbergioides* tree in centre. Interview Island, North Andamans.

S. K. Seth



ANDAMANS MOIST DECIDUOUS FOREST

A group of *Terminalia bialata*. Woodleys Island, Middle Andamans.

S. K. Seth

FLORISTICS.—

(i) *Andamans.*—

*Oxytenanthera nigrociliata.**

(ii) *Cachar* (moist).—

*Melocanna bambusoides.**

(iii) *N. Cachar.*—

*Bambusa tulda.**

(iv) *E. Himalayas.*—

*Dendrocalamus hamiltonii**.

GROUP 3. TROPICAL MOIST DECIDUOUS FORESTS

Sub-group 3A. Andamans Moist Deciduous Forests

C1. Andamans moist deciduous forest

DESCRIPTION.—There is typically a somewhat irregular top storey of predominantly deciduous trees about 40 m. or more in height, many of the trees being of very large girth and heavily buttressed. Beneath these trees is a rather definite second storey of numerous species including some evergreens, though most are deciduous, and there is a fairly complete shrubby evergreen undergrowth, including patches of bamboo. Climbers are heavy and often include canes.

DISTRIBUTION.—Met with throughout the Andaman Islands covering nearly half their total area. There appears to be a limited area of similar forest in the Nicobars.

LOCALITY FACTORS.—The climatic data given on p. 108 for Port Blair are probably fairly representative. The underlying rock is chiefly rather hard coarse grained sandstone with bands of shale and conglomerate, and the soil which is often shallow, is a sandy or clayey loam of light yellowish colour. The type is confined to the hilly ground and does not extend much above 100 m. where it is displaced by tropical evergreen, nor does it occur on the flat alluvial ground where the low evergreen forest described on p. 62 is in possession.

ILLUSTRATIONS.—Plates 15 and 16.

FLORISTICS.—

(i) *Andaman Is.* (CHENGAPPA, ETC.)—

I. *Pterocarpus dalbergioides** (S/D), *Terminalia bialata** (D), *T. manii**, *T. procera* (D), *Canarium euphyllum*, *Pterocymbium tinctorium* (E), *Salmalia insignis* (D), *Lagerstroemia hypoleuca* (D), *Tetrameles nudiflora* (D), *Chukrasia tabularis* (S/D), *Albizzia lebbek* (D).

II. *Lannea coromandelica*, *Adenanthera pavonina* (D), *Dillenia pentagyna*, *Diospyros marmorata* etc. (E), *Saccopetalum tectonum* (E), *Sageraea elliptica*, *Crotoxylon formosum*, *Semecarpus kurzii*, *Cinnamomum* spp., *Pterospermum aceroides*.

IIa. *Oxytenanthera nigrociliata, Bambusa schizostachyoides.*

IIIa. *Murraya paniculata, Atalantia monophylla, Pleiopermium alatum, Canthium gracilipes, Ixora grandifolia.*

IIIb. *Rinorea bengalensis, Mallotus acuminatus, Glycosmis pentaphylla, Licuala peltata.*

V. *Ventilago madraspatana, Delima sarmentosa, Harrisonia* spp., *Buettneria andamanensis, Acacia pennata, Entada phaseoloides, Calamus* spp.

NOTE.—This type is unquestionably a stable preclimax to the tropical evergreen determined by the soil which is such that it dries out considerably in the period January—April in which but little rain falls. Although the forests have not until recently suffered from the hand of man, the planned management to which they are being subjected is unquestionably altering their character, the regenerated stands being more predominantly deciduous in character. It is possible that this forest might in part be classified with the semi-evergreen.

(ii) *Great Nicobar Is.* (SAHNI)—

I. *Terminalia procera**, *T. bialata**, *Albizzia* spp., *Pterocymbium tinctorium.*

V. Climbers are numerous.

NOTE.—This type occurs only in small strips along the coast and would appear to have edaphic climax status, evergreen and deciduous vegetation being very much mixed. *Pterocarpus dalbergioides* is apparently absent.

C1/2S1. Andamans secondary moist deciduous forest

DESCRIPTION.—A more or less evenaged pole crop.

DISTRIBUTION.—Worked over areas of the primary type.

LOCALITY FACTORS.—As for the primary type.

ILLUSTRATION.—Plate 17.

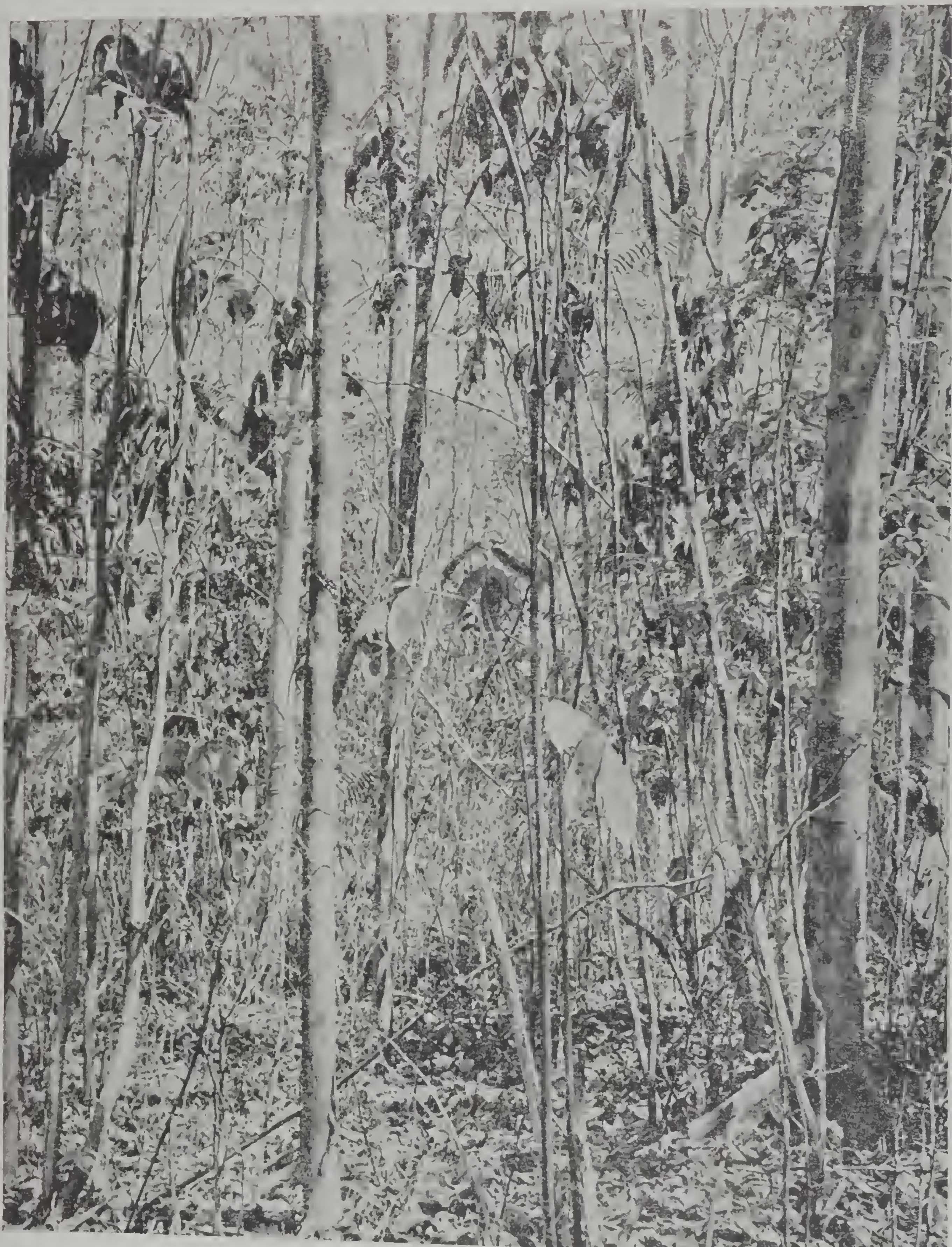
FLORISTICS.—

Andamans (*regenerated area semi-evergreen type*) (BHARGAVA)—

I. *Canarium euphyllum**, *Pterocymbium tinctorium**, *Salmalia insignis**, *Sideroxylon longepetiolatum, Tetrameles nudiflora, Terminalia bialata**, *Parishia insignis.*

II. *Pterocarpus dalbergioides**, *Lagerstroemia hypoleuca**, *Terminalia manii**, *T. procera**, *Artocarpus chaplasha, A. lakoocha, Albizzia lebbek, Adenanthera pavonina, Planchonia andamanica, Diploknema butyracea, Aphanamixis polystachya.*

Where the parent crop was semi-evergreen, the regenerated crop is more akin to moist deciduous with a lower proportion of padauk and evergreens partly as the result of sowing or broadcasting seed of deciduous species and burning. In moist deciduous types, the crop is essentially similar to the primary form. Two canopies are easily distinguishable, the top canopy consisting of fast-growing soft timber species, notably *Salmalia, Pterocymbiun, Canarium* and *Terminalia bialata* (40% in all), whilst the lower canopy is composed of slower growing hardwoods such as *Pterocarpus, Lagerstroemia* and *Terminalia procera* (60% in all).



ANDAMANS SECONDARY MOIST DECIDUOUS FOREST

Pterocarpus dalbergioides, *Terminalia procera* and other deciduous species (1948 regeneration area). Kyitaung, Middle Andamans.

S. K. Seth

Comparison with the Andamans climax moist deciduous forest (3A/C1) on page 103 shows the essential identity between the primary and secondary forms, except for the composition of the emergent and lower layers and the consequent difference in structure on maturity.

Sub-group 3B. South Indian Moist Deciduous Forests

1. NOMENCLATURE

Maharashtra	Wet mixed deciduous forest. Moist deciduous forest (with and without teak). (Moist) teak forest.
Madhya Pradesh	Monsoon forest. (Moist) teak forest.
Mysore, Madras and Kerala . . .	Moist deciduous forest. Monsoon forest.

2. GENERAL DESCRIPTION

Closed high forest commonly 30—36 m. or more in height, the dominant species being mostly deciduous though often only briefly so in comparison with the following types. Although intimate mixture of species is the rule, a relatively small number of species together form the greater part of the canopy and relatively pure associations are fairly frequently met with. Some evergreen dominants are included, but they are few, the evergreen habit is more developed in the lower storey giving the forest as a whole a more or less evergreen appearance most of the year.

A bamboo undergrowth is characteristic though locally absent, in which case the evergreens are commonly better developed. Canes are restricted to wet ground, and epiphytes mostly to post-climaxes in damp shady places; climbers are abundant and large. The undergrowth has usually been very greatly influenced by fires which traverse much of the type often maintaining it as a stable sub-climax to Group 1 or 2 though it would be recruited to some extent from Group 5 with fire protection.

The undisturbed soil cover would also consist mainly of more or less evergreen shrubs with but little grass, but the fires result in the spread of the grass which often becomes heavy and continuous especially where the canopy is open. The absence of small trees and saplings of the large tree species is often very marked and is also ascribable to repeated burning and grazing; teak seedlings seem best adapted to survive these injuries.

The term "monsoon forest" cannot reasonably be restricted to these types as it unduly stresses a pattern of precipitation which is a common feature of most of the types of vegetation occurring in India, especially Groups 3 and 5 and parts of 2 and 6.

The chief feature of the moist deciduous forests is a leafless period in the dry season which may or may not begin with the cold weather but is typically most general in March-April when the upper canopy is almost entirely leafless though there is often a good sprinkling of evergreens in the underwood and shrub cover. An appreciable number of the deciduous trees, however, come into new leaf (and often flower) long before the monsoon, unexpectedly spreading their new foliage at a time when one would expect them to experience great difficulty in obtaining enough moisture for the intense transpiration which must take place. Teak drops its leaves early in the cold weather in localities which are relatively dry or cold, but is almost evergreen in the moistest parts of its distribution. *Cedrela toona* and *Dalbergia sissoo* come into new leaf in March-April and carry a full canopy all through the hot weather. *Terminalia tomentosa*, *Adina*, *Lannea* and many others gradually drop their foliage during the cold and dry seasons and do not leaf again till rain falls. Cold seems to prolong the leafless season. *Hymenodictyon* is an example of trees with a long deciduous period lasting from November to June. Quite a number of species flower while more or less leafless, e.g., *Salmalia*, *Cassia fistula*, *Sterculia* spp., *Erythrina*, *Lannea* or as they come into leaf, e.g. *Dalbergia sissoo*, etc.

3. DISTRIBUTION

Moist deciduous forests occur in all parts of India with medium rainfall, notably including the important moist teak bearing forests of India. Thus they are found all along the eastern side of W. Ghats.

Madhya Pradesh	Parts of Jabalpur and Mandla and Raipur Divisions.
Gujarat	Typical of the Dangs Division.
Maharashtra	Parts of Kolaba and Thana Divisions.
Mysore	Kanara, Mangalore and generally in the western moister parts of the State.
Madras	South Coimbatore, Tirunelveli Divisions.
Kerala	Nilambur, Wynaad, and generally where evergreen and semi-evergreen are absent.

4. LOCALITY FACTORS

Data are given in the table for selected localities covering the range under which this type of forest occurs, though as they are all outside the forests hardly one of them is a typical example.

Temperature.—The mean temperature of the year varies from 24°C to 27°C and the mean maximum from 43°C in the relatively dry central parts of the peninsula, to 35°C on the coast. The mean January temperature does not usually drop below 15·6°C though in the northern and most elevated localities it may fall a few degrees lower; the mean minimum shows a wide range from about 20°C on the coast in southern latitudes to 4·4°C in the continental north.

Temperature—(centigrade)

Tropical Moist Deciduous Forest

Month	Madhya Pradesh SEONI 615 m.			Madhya Pradesh JUBBULPORE 393 m.			Madhya Pradesh JAGDALPUR 553 m.			Maharashtra CHANDA 193 m.			Maharashtra BOMBAY 11 m.		
	Mean	Mean max.	Mean min.	Mean	Mean max.	Mean min.	Mean	Mean max.	Mean min.	Mean	Mean max.	Mean min.	Mean	Mean max.	Mean min.
January . .	18·6	26·0	11·1	17·1	25·2	8·8	18·9	27·7	10·2	21·3	29·6	13·0	23·9	28·4	19·3
February . .	20·6	28·3	12·7	19·0	27·4	10·6	21·8	30·3	13·3	23·9	32·4	15·3	24·1	28·4	19·7
March . .	25·2	33·3	17·1	24·0	33·1	14·9	26·3	35·0	17·6	28·3	37·1	19·4	26·2	31·1	22·2
April . . .	29·5	37·5	21·4	29·2	38·1	20·2	29·4	37·3	21·6	32·6	40·8	24·4	28·1	31·7	24·5
May . .	32·2	39·8	24·6	31·8	40·8	22·7	31·2	38·6	23·7	37·4	43·0	27·8	29·7	32·8	26·4
June . . .	29·6	35·1	34·1	31·3	36·7	25·9	28·4	33·2	23·6	32·1	37·6	26·6	28·7	31·4	25·9
July . . .	25·7	28·9	22·4	27·0	30·2	23·7	25·2	28·3	22·2	27·8	31·3	24·3	27·2	29·7	24·6
August . .	25·1	28·2	21·9	26·2	29·2	23·1	25·1	28·3	21·8	27·4	30·7	24·0	27·0	29·4	24·5
September . .	25·4	29·4	21·3	26·5	30·6	22·4	25·3	29·3	21·4	27·6	31·6	23·6	27·0	29·7	24·3
October . .	24·1	30·2	17·8	24·3	31·0	17·5	24·2	29·4	18·9	26·1	32·1	20·1	27·9	31·6	24·2
November . .	20·2	27·4	12·9	19·6	27·9	11·3	20·8	27·2	14·4	23·3	29·6	15·0	27·2	31·9	22·5
December . .	17·9	25·4	10·3	16·6	25·1	8·1	17·9	26·0	9·8	19·8	28·1	11·6	25·4	30·3	20·4
M. A. T. . .	24·5	..	..	24·5	..	..	24·6	..	..	27·1	..	..	26·8	..	..
Annual mean maximum . .	30·8	..	..	31·3	..	..	30·9	..	..	33·7	..	..	30·4	..	..
Highest record .	44·4	..	..	46·1	..	..	46·1	..	..	48·3	..	..	38·3	..	..
Annual mean minimum . .	18·2	..	..	17·6	..	..	18·2	..	..	20·4	..	..	23·2	..	..
Lowest record .	2·8	..	..	0·0	..	..	4·4	..	..	2·8	..	..	11·7	..	..
No. of years . .	60	..	..	60	..	..	30	..	..	60	..	..	60		

Temperature—(centigrade)—concld.

Tropical Moist Deciduous Forest

Month	Orissa KORAPUT 911 m.			Mysore BELGAUM 780 m.			Kerala COCHIN 3 m.			Kerala TRIVANDRUM 61 m.			Andaman Islands PORT BLAIR 80 m.		
	Mean	Mean max.	Mean min.	Mean	Mean max.	Mean min.	Mean	Mean max.	Mean min.	Mean	Mean max.	Mean min.	Mean	Mean max.	Mean min.
January . .	19·1	26·5	11·6	21·6	28·8	14·3	26·8	30·5	23·1	26·4	31·2	21·7	25·5	29·0	22·0
February . .	22·3	29·0	15·5	23·2	31·3	15·2	27·4	30·6	24·2	27·6	31·9	23·2	25·6	29·7	21·4
March . .	24·9	31·8	18·0	25·9	34·2	17·6	28·3	31·1	25·6	28·5	32·7	24·3	26·4	30·8	21·9
April . . .	27·1	33·5	20·6	27·1	34·0	20·2	28·7	31·4	25·9	28·6	32·3	24·9	27·7	31·7	23·7
May . . .	26·6	32·0	21·2	27·1	34·0	20·2	28·3	30·8	25·7	29·3	32·8	25·8	27·2	30·4	23·9
June . . .	26·8	31·2	22·3	23·9	27·6	20·2	26·5	29·0	23·9	27·1	30·5	23·8	26·5	29·1	23·9
July . . .	23·1	25·8	20·2	22·1	24·6	29·7	25·9	28·1	23·7	26·3	29·4	23·2	26·4	28·8	23·9
August . .	23·2	26·1	20·3	22·0	24·7	19·3	25·9	28·0	23·9	26·4	29·5	28·3	26·2	28·6	23·7
September . .	23·1	26·2	20·1	22·6	26·3	18·7	26·2	28·3	24·1	27·1	30·7	23·4	25·8	28·4	23·2
October . .	21·8	24·0	19·7	22·8	28·6	17·1	26·6	29·1	24·1	26·8	30·4	23·1	26·0	28·8	23·2
November . .	18·1	21·3	14·8	23·3	28·2	16·4	26·9	29·8	24·1	26·6	30·2	23·0	26·0	28·8	23·1
December . .	16·1	22·3	9·7	21·2	27·8	14·7	26·9	30·3	23·4	26·2	30·4	22·0	25·7	28·7	22·7
M. A. T. . .	22·7	..	..	23·5	..	..	27·1	..	..	27·4	..	..	26·3	..	..
Annual mean maximum . .	27·5	..	..	29·3	..	..	29·8	..	..	31·0	..	..	29·4	..	..
Highest record .	?	..	..	40·6	..	..	33·9	..	..	33·9	..	..	36·1	..	..
Annual mean minimum . .	17·8	..	..	17·8	..	..	24·3	..	..	23·9	..	..	23·1	..	..
Lowest record .	?	..	..	6·7	..	..	17·8	..	..	18·9	..	..	16·7	..	..
No. of years. .	upto (1955)	..	..	60 (to 1940)	..	..	60	..	..	60	..	..	60	..	..

Rainfall and Humidity.—Rainfall data for some of the stations of the last table and a few representative more typical localities for which temperature data are lacking, are given in the table on page 110.

The first two stations are at the dry limit of the type, in fact very probably beyond it, the type occurring either as a post-climax or in localities with better rainfall than the indicating station. At the opposite extreme come Nilambur and Trivandrum with the rainfall well distributed; it is possible that in these localities the moist deciduous is only a fairly stable preclimax to semi-evergreen. Yellapur and Belgaum represent the wet and dry limits of the Central Western Ghats. It may be said that the typical rainfall for the type as a climax is 1,500 to 2,000 mm. with a dry season of 4-5 months; with a longer dry season the range extends to still higher rainfalls. As a stable preclimax with burning, the type predominates with much higher rainfalls even with very favourable distribution.

Rock and Soil.—The type is found on practically every soil occurring in India within the tropics, from recent sandy alluvium to old red soils *in situ.* Although not attaining its best development on them, it occupies most of the pronouncedly lateritic soils, and it may be met with even on black cotton soils though these are usually associated with a drier climate and so carry dry deciduous or thorn forest. Semi-evergreen forest will frequently be found on favourable sites and soils whilst near the drier climatic extreme, dry deciduous forest may be very intimately intermixed with it, occupying exposed aspects, dry ridges and shallow or impervious soils. With a climate appropriate to wet evergreen forest, this type may predominate on rapidly drained slopes with porous soils.

Topography.—The greater part of this forest type is on hilly ground, but this is mainly due to the destruction of the forest on the flatter culturable tracts.

5. GENERAL FLORISTICS

In the teak-bearing forests *Tectona grandis* is the most characteristic species independently of its economic importance and it of excellent development wherever the soil permits. In the top canopy it is generally associated with *Terminalia* spp., *Pterocarpus* spp. and *Lagerstroemia* spp. *Adina* is often present though tending to indicate drier conditions, and *Dalbergia latifolia* is characteristic; *Xylia* is also very generally present, and *Schleichera* and *Careya* are common, mainly in the second storey. The typical bamboo is *Bambusa arundinacea, Dendrocalamus strictus* only appearing at the dry end; as noted, however, bamboos are not invariably present. In the non-teak-bearing type a variety of moist and occasionally evergreen species occur in mixture.

Rainfall—(millimetres)

Tropical Moist Deciduous Forest

Months	M.P. SEONI 615 m.	M.P. JUBBULPORE 393 m.	M.P. JAGDALPUR 553 m.	Maharashtra CHANDA 193 m.	Maharashtra BOMBAY 11 m.	Mysore YELLAPUR 565 m.	Orissa KORAPUT 911 m.	Mysore BELGAUM 780 m.	Kerala NILAMBUR 30 m.	Kerala COCHIN 3 m.	Kerala TRIVANDRUM 61 m.	Andaman Islands PORT BLAIR 80 m.
	Rainfall mm.	Rainfall mm.	Rainfall mm.	Rainfall mm.	Rainfall mm.	Rainfall mm.	Rainfall mm.	Rainfall mm.	Rainfall mm.	Rainfall mm.	Rainfall mm.	Rainfall mm.
January . . .	14	21	10	8	4	2	4	3	5	23	20	45
February . . .	21	19	27	21	2	1	8	1	4	20	19	28
March . . .	20	14	14	20	1	8	19	10	13	51	39	28
April . . .	15	8	45	20	1	35	36	45	67	25	116	60
May . . .	19	16	60	16	17	56	62	58	152	297	223	384
June . . .	217	179	246	205	484	510	213	206	671	725	335	562
July . . .	412	492	384	414	617	964	417	434	871	592	197	392
August . . .	338	431	414	320	340	555	419	245	426	353	120	414
September . .	218	214	264	226	264	184	274	122	194	195	115	442
October . . .	58	48	111	52	65	136	106	121	263	340	273	318
November . .	17	11	29	17	14	41	33	39	118	170	177	267
December . .	13	9	4	7	2	7	7	9	22	41	63	201
Total for year(M.A.R.)	1,363	1,462	1,607	1,324	1,809	2,498	1,597	1,294	2,805	2,929	1,697	3,143
No. of rainy days .	70	65	83	63	74	105	87	81	115	130	97	150
No. of months less than 60 mm. . .	7	8	6	7	6	6	6	6	4	3	3	3
M. A. Humidity .	52	55	53%	56%	74	63	?	66%	?	79	80	81
No. of years . .	60	60	30	60	60	?	?	?	70	60	100	60

6. SUBDIVISIONS, SUCCESSIONS, Etc.

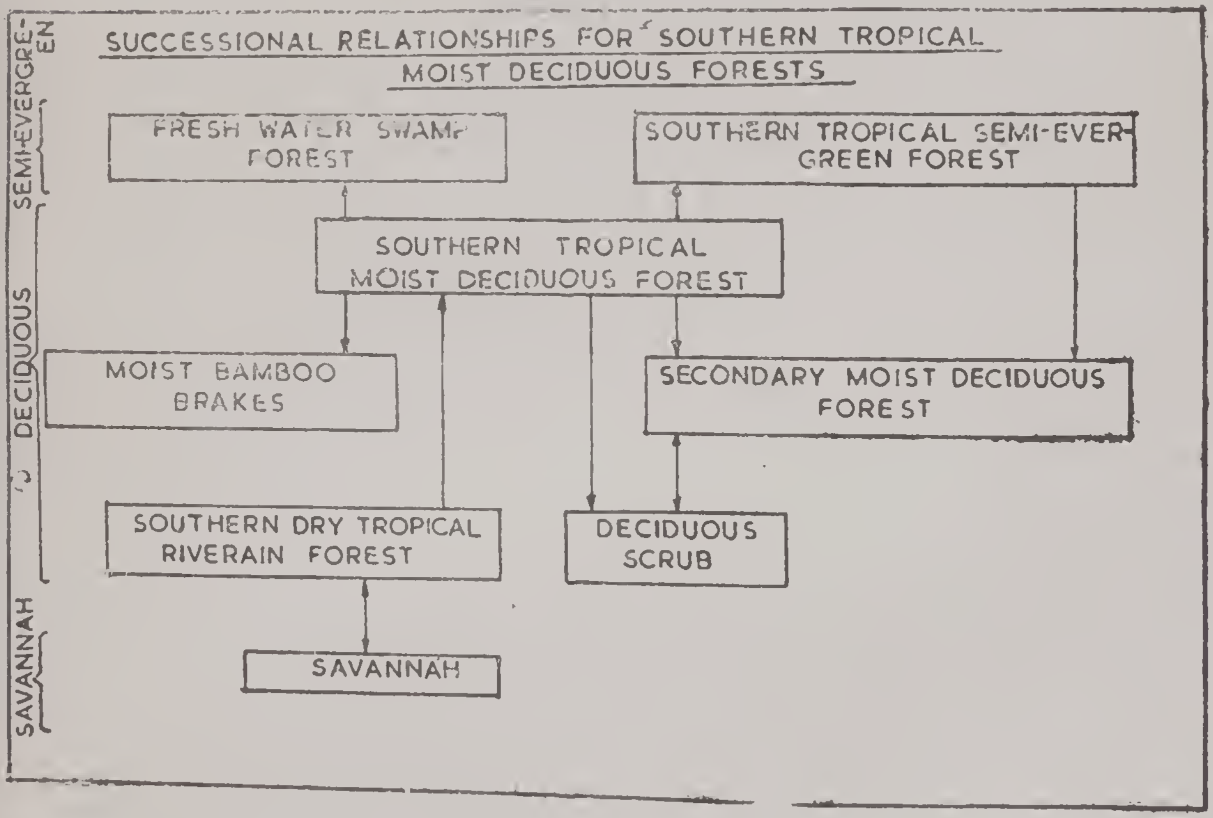
The type is very uniform throughout its range, and the local variants appear to differ mainly owing to the different floras from which they are derived.

The primary sere on new riverain soils passes through a drier deciduous phase and may lead to a semi-evergreen post-climax of considerable stability. There should be an estuarine primary sere leading up to this type but no records are available. The secondary seres as usual are more xerophytic and so tend to resemble dry deciduous forest. The following types are differentiated :—

C1—Moist teak-bearing forest.

C2—Southern moist mixed deciduous forest (without teak).

2S1—Southern secondary moist mixed deciduous forest.


SUCCESSIONAL RELATIONSHIPS FOR SOUTHERN TROPICAL MOIST DECIDUOUS FORESTS
SEMI-EVERGREEN
DECIDUOUS
SAVANNAH
FRESH WATER SWAMP FOREST
SOUTHERN TROPICAL SEMI-EVERGREEN FOREST
SOUTHERN TROPICAL MOIST DECIDUOUS FOREST
MOIST BAMBOO BRAKES
SECONDARY MOIST DECIDUOUS FOREST
SOUTHERN DRY TROPICAL RIVERAIN FOREST
DECIDUOUS SCRUB
SAVANNAH

C1. Moist Teak-bearing forests

DESCRIPTION.—A general description is given on p. 109. There are, however, significant floristic and environmental differences on the basis of which three subtypes can usefully be differentiated.

C1a—Very moist teak forest

Typical rainfall over 2,500 mm; deep alluvial often clayey soils; low (upto 10) percentage of teak; very dense evergreen undergrowth; little natural regeneration; fires nil; grazing negligible.

C1b—Moist teak forest

Typical rainfall 1,600 to 2,500 mm; deep loamy soils; fair to medium (10 to 25) percentage of teak; dense undergrowth; fair but patchy natural regeneration; fires rare; light grazing.

C1c—Slightly moist teak forest

Typical rainfall 1,200 to 1,600 mm; moderately deep loamy soils; medium to high (20 to 60) percentage of teak; moderate undergrowth; fair natural regeneration; occasional fires; moderate grazing.

DISTRIBUTION.—Met with throughout the Peninsula wherever the rainfall exceeds 1,300 mm. (except on the Karnatak Coast) from the neighbourhood of Surat and Hoshangabad southwards. Mainly found as a strip down the east side of the crest of the Ghats with outliers further east in Maharashtra and Madhya Pradesh (well exemplified by the Bori forests below Pachmarhi and the Allapalli forests of S. Chanda) and adjoining country.

LOCALITY FACTORS.—As indicated above.

C1a. Very moist teak forest

The floristics correspond to the moister end of the moist deciduous, approaching the semi-evergreen. Site quality high, I to II; teak forming a low proportion of the overwood, usually not exceeding 10%. Some of the forests are evidently of secondary origin on semi-evergreen sites, stabilised as a sub-climax. Characteristic species are the following.

I. *Grewia tiliaefolia*, *Lagerstroemia lanceolata*.

II. *Dillenia pentagyna*, *Kydia calycina*.

IIa. *Bambusa arundinacea* (o).

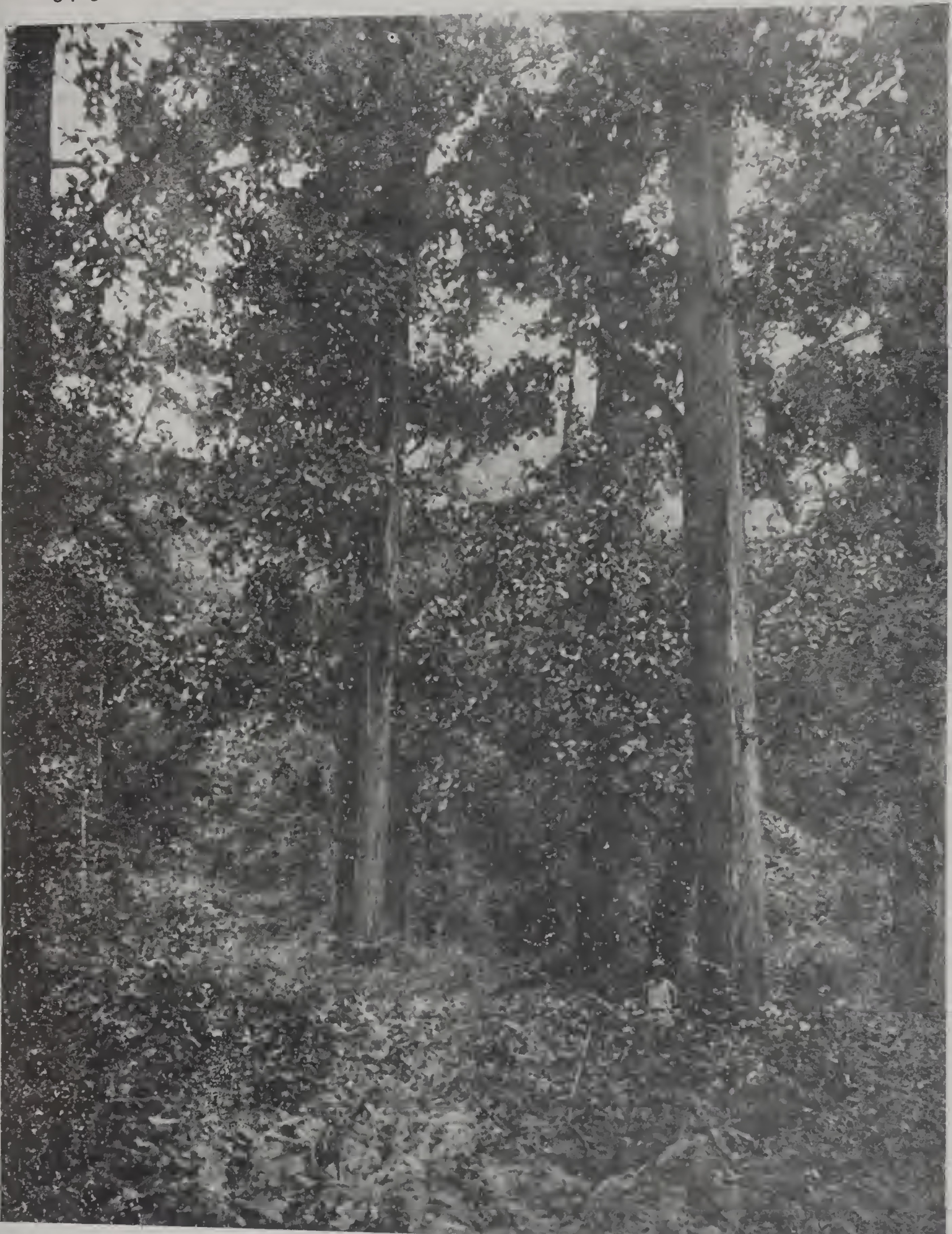
III. *Glycosmis pentaphylla*, *Clerodendrum viscosum*.

ILLUSTRATION.—Plate 18.

FLORISTICS.—

(i) *Muthodi, Bhadravati Division, Mysore*—

I. *Terminalia crenulata** (a), *Grewia tiliaefolia** (o), *Dalbergia latifolia* (o), *Terminalia paniculata* (f), *T. bellerica* (f), *Tectona grandis** (f), *Lagerstroemia lanceolata**, *Dillenia pentagyna* (f), *Adina cordifolia* (f), *Pterocarpus marsupium* (f).



VERY MOIST TEAK FOREST

Tectona grandis with *Terminalia paniculata*, *T. tomentosa*, *Lagerstroemia lanceolata* etc. with complete shrubby and herbaceous undergrowth.
Palakadava, S. Coimbatore Division, Madras.

II. *Xylia xylocarpa* (la), *Kydia calycina* (f).

IIa. *Bambusa arundinacea* (la), *Dendrocalamus strictus* (high quality), *Oxytenanthera monostigma* (lo).

III. *Clerodendrum viscosum*, *Leea*, etc.

IVb. Grass is present wherever burning takes place.

V. *Butea parviflora* (f).

(ii) *Begur, Manantoddy, Wynaad, Kerala*—

I. *Terminalia crenulata** (a), *Garuga pinnata* (o), *Salmalia malabarica* (o), *Tectona grandis** (f), *Grewia tiliaefolia** (f), *Lagerstroemia lanceolata** (f), *Stereospermum suaveolens* (f), *Dalbergia latifolia* (f), *Terminalia bellerica* (lf), *Melia composita* (lf), etc.

II. *Emblica officinalis* (o), *Kydia calycina* (f), *Wrightia* sp. (f), *Cordia dichotoma* (f), *Schleichera oleosa* (lf) etc.

IIa. *Bambusa arundinacea** (la).

III. *Lantana** (va), *Glycosmis pentaphylla* (lf), *Ardisia* sp. (lf).

IVb. Light grass.

V. *Dalbergia volubilis* (o), *Butea parviflora* (f), *Acacia pennata* (f).

Note.—The forests have been frequently burnt in the past and much of the bigger teak has been worked out.

(iii) *Mount Stuart, S. Coimbatore, Madras*—

I. *Lagerstroemia lanceolata** (a), *Terminalia paniculata** (a), *Grewia tiliaefolia** (a), *Mitragyna parvifolia* (o), *Stereospermum personatum* (o), *Radermachera xylocarpa* (o), *Vitex altissima* (o), *Terminalia crenulata** (f), *Tectona grandis** (f), *Adina cordifolia* (f), *Dillenia pentagyna* (f), *Salmalia malabarica* (lo).

II. *Cycas circinalis* (o), *Emblica officinalis* (f), *Zizyphus xylopyrus* (f).

IIa. *Bambusa arundinacea** (c).

III. *Lantana** (va), *Helicteres* (a), etc.

IVb. *Imperata* (lf) and finer grasses.

V. *Convolvulaceae* (a), *Butea parviflora* (f), *Zizyphus oenoplia* (f), *Caesalpinia mimosoides* (la).

Note.—This forest immediately adjoins tropical evergreen and must in part be preclimax. It still gets burnt at intervals accounting for absence of evergreen under growth.

(iv) *Trichur, Malayattur, Kerala*—

I. *Adina cordifolia, Albizzia odoratissima, A. procera, Alstonia scholaris, Salmalia malabarica, Cedrela toona, Dalbergia latifolia, Grewia tiliaefolia*, Holoptelea integrifolia, Hymenodictyon excelsum, Lagerstroemia lanceolata*, L. speciosa, Lannea coromandelica, Miliusa velutina, Pterocarpus marsupium, Schleichera oleosa, Spondias pinnata, Radermachera xylocarpa, Tectona grandis*, Terminalia bellerica, T. paniculata*, T. tomentosa*., Vitex altissima, Xylia xylocarpa, Machilus macrantha.*

II. *Bauhinia malabarica, Bridelia retusa, Careya arborea, Cassia fistula, Dillenia pentagyna, Erythrina stricta, Evodia lunu-ankenda, Ficus* sp., *Gmelina arborea, Macaranga peltata, Sterculia villosa, S. urens, Strychnos nux-vomica, Fagara budrunga, Albizzia chinensis.*

IIa. *Bambusa arundinacea* (*Ochlandra* occurs occasionally).

III. *Callicarpa lanata, Clerodendrum viscosum, Cycas circinalis, Flueggea* sp., *Glycosmis pentaphylla, Helicteres isora, Hibiscus furcatus, Holarrhena antidysenterica, Lantana camara, Randia dumetorum, Urena lobata.*

V. *Acacia intsia, A. pennata, Bauhinia vahlii, Caesalpinia bonduc, Calycopteris floribunda, Butea parviflora, Calamus* occurs occasionally.

(v) *Punalur, Thenmala, Kerala*—

I. *Terminalia tomentosa*, T. paniculata*, T. bellerica, Stereospermum personatum, Dalbergia latifolia, Pterocarpus marsupium*, Radermachera xylocarpa, Salmalia malabarica, Adina cordifolia, Hymenodictyon excelsum, Grewia tiliaefolia*, Lagerstroemia lanceolata, Xylia xylocarpa*, Tectona grandis*, Vitex altissima, Sterculia villosa, Lannea coromandelica.*

II. *Buchanania lanzan, Careya arborea, Strychnos nux-vomica, Dillenia pentagyna, emecarpus anacardium, Cycas circinalis, Miliusa velutina, Emblica officinalis, Ixora nigricans, Olea dioica, Mitragyna parvifolia, Cipadessa fruticosa, Aporosa lindleyana, Mallotus philippensis, Schleichera oleosa.*

IIa. *Bambusa arundinacea.*

III. *Helicteres isora, Clerodendrum viscosum, Leea* sp., *Desmodium* sp., *Melanthesa* sp., *Zizyphus* sp., *Glycosmis pentaphylla, Eupatorium* sp., *Ixora coccinea, Memecylon* sp., *Osbeckia* sp.

MOIST TEAK FOREST

Mixed moist deciduous forest containing some teak. Dangs Division, Gujarat.

S. K. Seth

MOIST TEAK FOREST

A view of the preservation plot "Glory of Allapalli", South Chanda Division, Maharashtra.

S. K. Seth

IVb. *Imperata cylindrica, Andropogon* sp., *Eragrostis* sp.

V. *Lantana camara, Acacia intsia, A. pennata, Pterolobium indicum, Caesalpinia mimosoides, Calycopteris floribunda, Butea parviflora, Zizyphus oenoplia, Butea superba, Entada phaseoloides, Bauhinia vahlii.*

C1b. Moist teak forest

Deciduous associates predominate in this subtype. Teak is usually of II—III quality, forming a fair to medium proportion of the overwood. Some of the forests may be secondary in origin. Characteristic species are the following :—

I. *Terminalia tomentosa, Dalbergia latifolia.*

II. *Xylia xylocarpa.*

IIa. *Bambusa arundinacea* (o), *Dendrocalamus strictus* (a).

ILLUSTRATIONS.—Plates 19 and 20.

FLORISTICS.—

(i) *Bori, Hoshangabad Division, Madhya Pradesh*—

I. *Tectona grandis** (a), *Terminalia tomentosa** (a), *Adina cordifolia* (a), *Pterocarpus, marsupium* (f), *Dalbergia latifolia* (o), *Lannea coromandelica* (f), *Lagerstroemia parviflora* (f), *Anogeissus latifolia* (o), *Diospyros tomentosa* (o).

II. *Schleichera oleosa* (o), *Ougeinia oojeinensis* (f), *Emblica officinalis* (f), *Miliusa tomentosa* (f), *Chloroxylon swietenia* (f), *Careya arborea* (o).

IIa. *Dendrocalamus strictus* (good quality Ia).

III. *Helicteres isora* (a), *Petalidium barlerioides, Gymnosporia spinosa, Phoenix acaulis, Lantana camara.*

IVa. *Triumfetta rotundifolia, Cassia tora.*

IVb. *Themeda quadrivalvis, Sorghum halepense, Dichanthium annulatum* etc.

V. *Millettia auriculata* (a), *Cryptolepis buchanani* (o), *Bauhinia vahlii* (f), *Butea superba* (f), *Ventilago madraspatana* (f), *Acacia caesia* (o).

(ii) *Allapalli, South Chanda Division, Maharashtra*—

I. *Tectona grandis** (va), *Terminalia tomentosa** (f), *Adina cordifolia* (f), *Dalbergia latifolia** (f) , *Madhuca indica* (f), *Pterocarpus marsupium* (o), *Mitragyna parvifolia* (f), *Lagerstroemia parviflora* (o), *Albizzia* spp., *Salmalia malabarica* (o), *Diospyros tomentosa, Careya arborea, Stereospermum personatum, Tamarindus indica.*

II. *Xylia xylocarpa**, *Grewia tiliaefolia*, *Cleistanthus collinus*, *Emblica officinalis*, *Schleichera olcosa*, *Diospyros montana*, *Ixora arborea*.

IIa. *Dendrocalamus strictus* (a).

III. *Helicteres isora*, *Petalidium barlerioides*, *Pogostemon plectranthoides*, *Indigofera* spp.

IVa. *Achyranthes aspera*.

IVb. *Sorghum halepense* (in open), *Imperata cylindrica*, *Heteropogon contortus*.

V. *Bauhinia vahlii*, *Butea superba*, *Calliopteris floribunda*, *Acacia* spp., *Combretum decandrum*.

(iii) *Dandeli*, *N. Kanara*, *Mysore*—

I. *Terminalia paniculata** (a), *T. tomentosa** (a), *Lagerstroemia lanceolata** (a), *Tectona grandis** (a), *Salmalia malabarica* (o), *Pterocarpus marsupium* (o), *Dalbergia latifolia** (f), *Dillenia pentagyna* (f), *Grewia tiliaefolia* (f), *Xylia xylocarpa** (f), *Bauhinia lawii* (lf).

II. *Xylia xylocarpa* (la).

IIa. *Dendrocalamus strictus* (a), *Bambusa arundinacea* (la), *Oxytenanthera monostigma* (lf).

III. *Lantana* (la).

V. *Acacia intsia** (a), *Mucuna prurita* (la).

(iv) *Palghat*, *Kerala*—

I. *Xylia xylocarpa**, *Terminalia paniculata**, *Anogeissus latifolia*, *Lagerstroemia lanceolata**, *Dalbergia latifolia**, *Albizzia odoratissima*, *A. lebbek*, *Salmalia malabarica*, *Pterocarpus marsupium*, *Kydia calycina*, *Lannea coromandelica*, *Terminalia tomentosa*, *Tectona grandis**, *Schleichera oleosa*.

II. *Wrightia tinctoria*, *Randia dumetorum*, *Mallotus philippensis*.

IIa. *Bambusa arundinacea*, *Dendrocalamus strictus*.

III. *Helicteres isora*, *Desmodium* sp., *Lantana*, *Eupatorium*.

C1c. Slightly moist teak forest

The proportion of dry deciduous associates is higher than in the last subtype. Site quality is III or lower; teak usually forms the major portion of the overwood. Characteristic species are the following :

I. *Terminalia tomentosa*, *Adina cordifolia*.

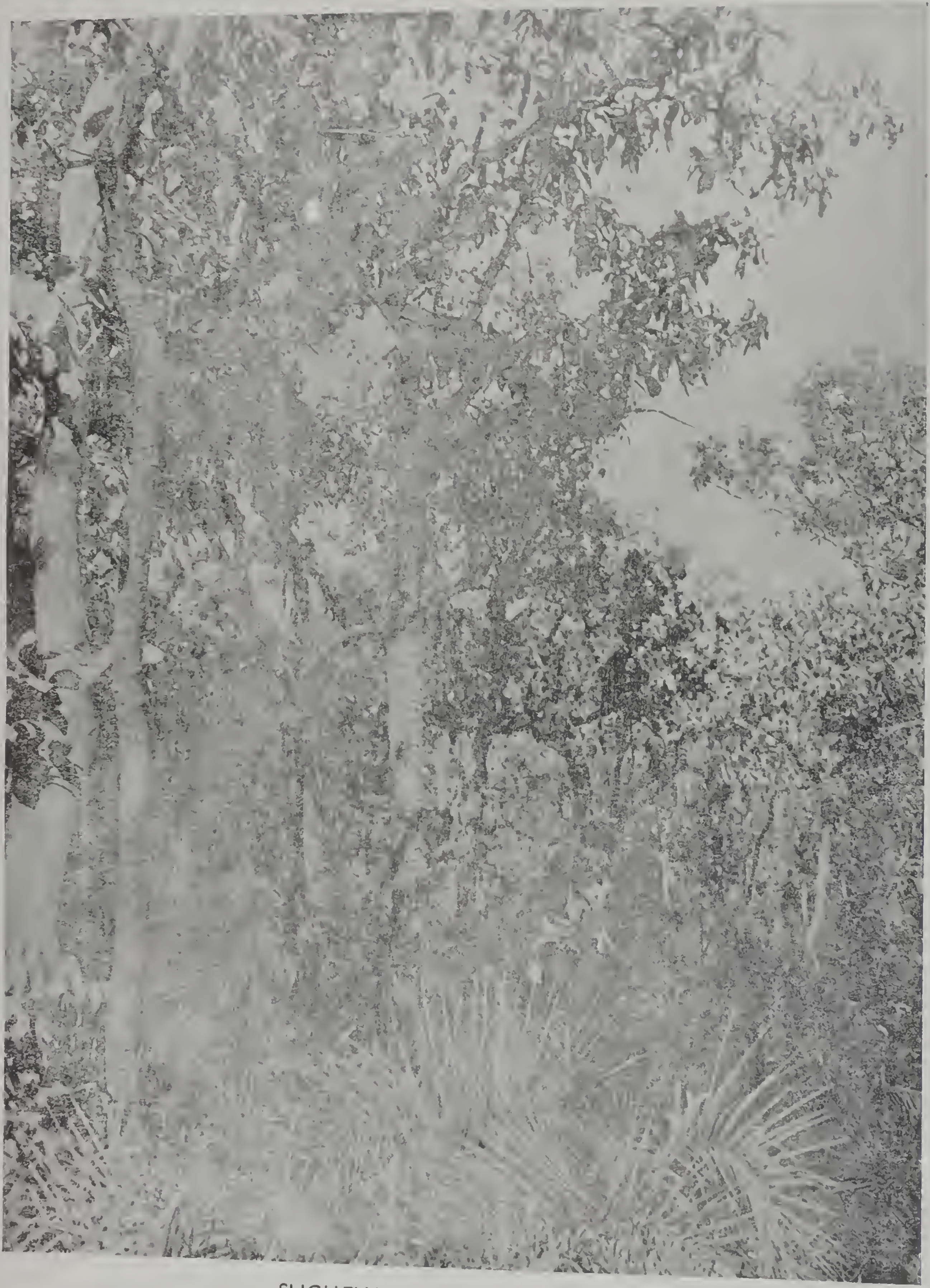
II. *Schleichera oleosa*.

IIa. *Dendrocalamus strictus* (a).

ILLUSTRATION.—Plate 21.

FLORISTICS.—

(i) *Bastar*, *Madhya Pradesh*—



SLIGHTLY MOIST TEAK FOREST

Transition to dry deciduous type, with teak and *Terminalia tomentosa* as the commonest trees; *Phoenix humilis* common in undergrowth.

Nallamalais, Kurnool West Division, Andhra Pradesh.

S. K. Seth

I. *Tectona grandis** (va), *Terminalia tomentosa** (a), *Adina cordifolia**, *Albizzia odoratissima, Salmalia malabarica, Dalbergia paniculata, Diospyros tomentosa.*

II. *Syzygium cumini, Miliusa tomentosa, Careya arborea, Mitragyna parvifolia.*

IIa. *Dendrocalamus strictus** (va).

III. *Ixora arborea, Clerodendrum viscosum, Lantana camara, Woodfordia fruticosa, Helicteres isora.*

IVb. *Imperata cylindrica.*

V. *Butea superba, Bauhinia vahlii, Combretum decandrum, Entada phaseoloides, Ichnocarpus frutescens.*

(ii) *Betul, Madhya Pradesh* (towards drier end)—

I. *Tectona grandis** (va), *Terminalia tomentosa** (a), *Lagerstroemia parviflora* (f), *Adina cordifolia** (o), *Dalbergia latifolia* (lf), *Pterocarpus marsupium* (f), *Terminalia bellerica* (o), *Anogeissus latifolia* (f), *Mitragyna parvifolia* (o), *Schrebra swietenioides* (o).

II. *Schleichera oleosa** (o), *Ougeinia oojeinensis* (f), *Emblica officinalis* (o), *Miliusa tomentosa, Buchanania lanzan* (o), *Flacourtia indica* (lf).

IIa. *Dendrocalamus strictus** (va).

III. *Desmodium* sp., *Helicteres isora* (f), *Gymnosporia spinosa* (lf), *Indigofera* (o), *Woodfordia fruticosa* (lf), *Barleria, Grewia hirsuta* (f), *Nyctanthes arbor-tristis* (lf).

IVa. *Ageratum, Sida, Triumfetta.*

IVb. *Themeda quadrivalvis, Heteropogon, Ischaemum* spp.

V *Millettia auriculata, Cryptolepis buchanani, Bauhinia vahlii, Butea superba.*

(iii) *Chedleth and Sultan's Battery, Kerala*—

I. *Terminalia tomentosa**, *Tectona grandis**, *Anogeissus latifolia** (mostly on the drier sites), *Lagerstroemia lanceolata, Pterocarpus marsupium, Dalbergia latifolia, Adina cordifolia, Salmalia malabarica, Stereospermum personatum.*

II. *Schleichera oleosa, Kydia calycina**, *Albizzia odoratissima, Bridelia retusa, Shorea talura.*

IIa. *Dendrocalamus strictus.*

III. *Wrightia tinctoria, Helicteres isora, Randia dumetorum, Allophyllum cobbe.*

V. *Acacia pennata, Butea parviflora.*

C2. Southern moist mixed deciduous forest

NOMENCLATURE.—Moist deciduous teak bearing forests (WORKING PLANS).

DESCRIPTION.—The general description applies. The evergreen component is usually larger than in the case of the teak-bearing forests, except for the very moist sub-type. Teak is present occasionally and may be an indicator of secondary succession.

DISTRIBUTION.—All along the Western Ghats and inland wherever the climate and soil are suitable.

LOCALITY FACTORS.—Usually in damp valleys; occasionally on high ground with shallow or porous soils, the rainfall corresponding to the wetter types.

ILLUSTRATION.—Plate 22.

FLORISTICS.—

(i) *Maharashtra* (SATYANARAYAN)—

I. *Tetrameles nudiflora*, *Stereospermum personatum*, *Dysoxylum binectariferum*, *Ficus nervosa* (all occasional).

II-i. *Syzygium cumini** (35%), *Olea dioica** (18%), *Pouteria tomentosa*, *Bridelia retusa* var. *squamosa*, *Mangifera*, *Actinodaphne angustifolia*, *Ficus glomerata*.

II-ii. *Memecylon umbellatum*, *Mallotus*, *Ixora*, *Flacourtia*, *Randia*.

III. *Callicarpa*, *Lasiosiphon*, *Phaylopsis*, *Leea*, *Pogostemon* etc.

IVb. Grass generally absent.

V. (Abundant) *Gnetum*, *Anodendron*, *Jasminum*, *Elaeagnus*, *Mezoneurum* etc.

(ii) *Chanda, Maharashtra*—

I. *Pterocarpus marsupium**, *Salmalia malabarica** (o), *Terminalia bellerica* (o), *Anogeissus latifolia* (f), *Dalbergia latifolia* (o), *Terminalia tomentosa*, *Lannea coromandelica*, *Madhuca indica*, *Garuga pinnata*.

II. *Miliusa tomentosa* (a), *Polyalthia cerasoides** (a), *Lagerstroemia parviflora* (o), *Emblica officinalis* (f), *Xylia xylocarpa* (o to f), *Grewia tiliaefolia* (o), *Schrebera swietenioides* (f), *Cleistanthus collinus* (f), *Diospyros montana* (o), *Flacourtia indica* (o).

IIa. *Dendrocalamus strictus*.

III. *Zizyphus oenoplia*, *Casearia graveolens* (a), *Helicteres isora*, *Desmodium gangeticum*.

IVb. Grasses present.

NOTE.—Very similar forest occurs in Andhra Pradesh with *Terminalia tomentosa* predominating accompanied by *Pterocarpus* (f), *Adina* (lf), *Salmalia* (o), *Grewia* (f).

(iii) *North Kanara, Mysore* (ARORA)—

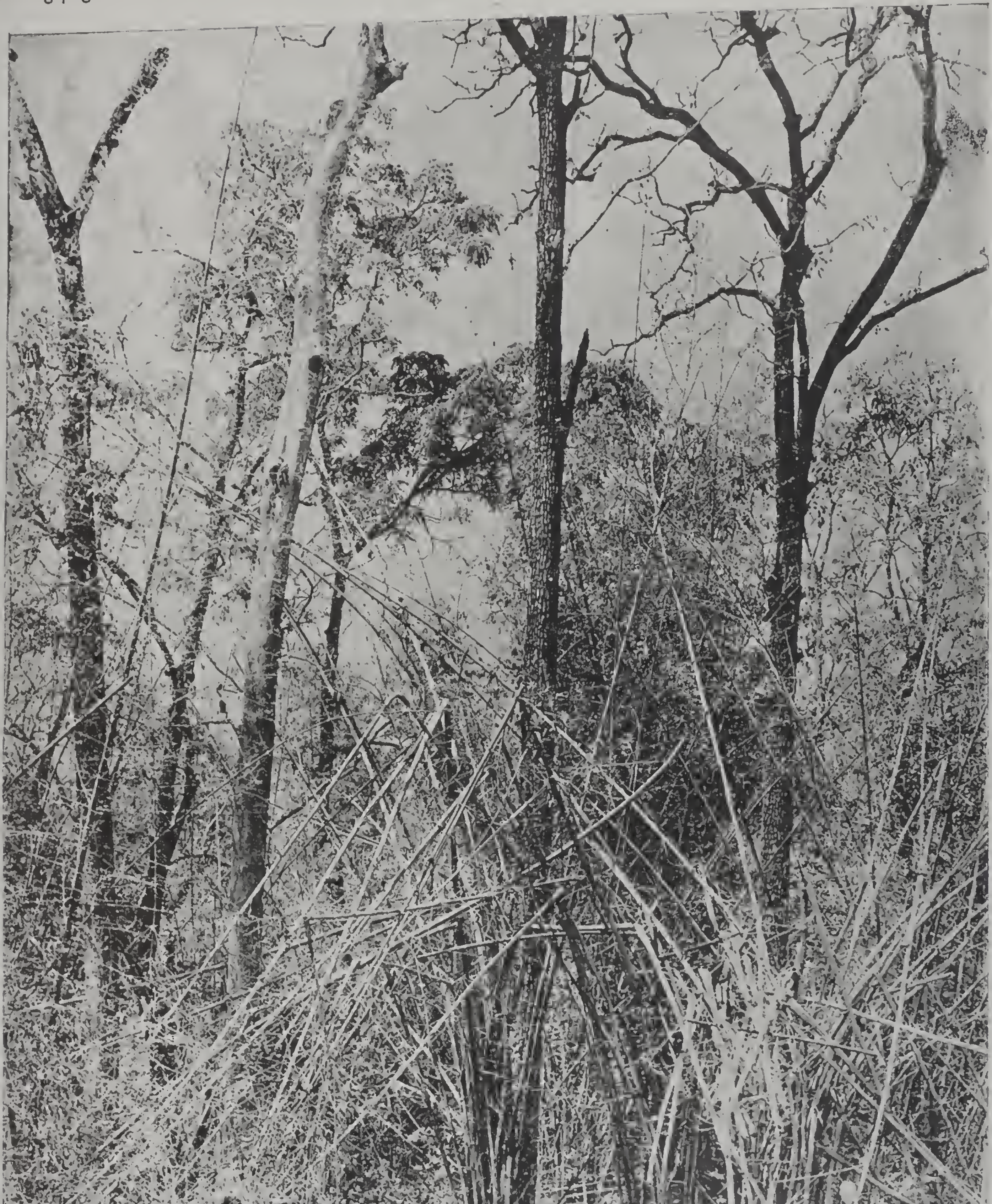
I. *Adina cordifolia**, *Grewia tiliaefolia*, *Madhuca indica*, *Dillenia pentagyna*, *Cinnamomum* (o), *Litsea* (o), *Olea dioica* (o).

II. *Emblica officinalis*, *Xylia xylocarpa* etc.

IIa. *Bambusa arundinacea*, *Dendrocalamus strictus*.

III. *Tabernaemontana* etc.

V. *Zizyphus rugosa*, *Cyclea*, *Acacia concinna*.



SOUTHERN MOIST MIXED DECIDUOUS FOREST
Terminalia tomentosa, *Lagerstroemia lanceolata* (smooth trunk), *Salmalia malabarica* (left), *Cedrela toona*, *Grewia tiliaefolia* with underwood of flowered out *Dendrocalamus strictus*. Kesave, Bhadravati Division, Mysore.

H. G. Champion

(iv) *Kerala* (ANSARI)—

I. *Terminalia paniculata**, *T. tomentosa**, *T. bellerica, Pterocarpus marsupium, Albizzia procera, Alstonia scholaris, Dillenia pentagyna, Bridelia retusa, Salmalia malabarica, Grewia tiliaefolia.*

II. *Xylia xylocarpa, Careya arborea, Callicarpa lanata, Cassia fistula, Strychnos nux-vomica.*

III. *Croton reticulatus, Anisomeles heyneana, Carissa carandas.*

(v) *Ranni, Kerala*—

I & II. *Terminalia paniculata**, *T. tomentosa, Pterocarpus marsupium, Anogeissus latifolia, Careya arborea, Buchanania lanzan, Emblica officinalis, Dillenia pentagyna, Salmalia insignis, Sterculia villosa, Albizzia odoratissima, Cassia fistula, Gmelina arborea, Taberaemontana heyneana, Bauhinia malabarica, Wrightia tinctoria.*

IVb. *Saccharum spontaneum.*

C2/2S1. Southern secondary moist mixed deciduous forest

NOMENCLATURE.—Usually included with the climax moist deciduous.

DISTRIBUTION.—Moist deciduous forest is found over considerable areas which experience the climate appropriate to tropical evergreen or at least semi-evergreen forest, soil and configuration being insufficient to account for the absence of the latter, and abrupt changes to it being encountered. This is conspicuous the whole length of the Western Ghats. There can be little doubt but that these forests are of secondary origin, the climatic climax having been displaced by human action direct (shifting cultivation), or indirect (grazing and burning outwards from settlements).

DESCRIPTION.—The forest is very similar to the climax moist deciduous but usually with few or no fine big trees and more of the soft quick growing species including figs. Scattered survivors of the primary forest are occasionally encountered especially in damp hollows. Whereas deciduous shrubs and thin grass form the ground cover with annual burning, fire protection results in the development of a dense evergreen undergrowth in which the deciduous trees cannot regenerate.

LOCALITY FACTORS.—Very usually hilly ground, with the climate of the semi-evergreen or evergreen forests though the soil is often shallow and stony through past exposure and erosion. Lateritic outcrops are frequently met with.

FLORISTICS.—

(i) *Parappa, S. Mangalore Division.*—

I. *Terminalia paniculata** (a), *Salmalia malabarica* (o), *Mangifera indica* (o), *Dalbergia latifolia* (o), *Adina* (o), *Lagerstroemia lanceolata* (o), *Terminalia crenulata* (f), *Dillenia pentagyna* (f), *Schleichera oleosa* (f), *Alstonia scholaris* (f), *Xylia xylocarpa* (la).

II. *Olea dioica** (a), *Holarrhena* (o), *Careya arborea* (o), *Emblica officinalis* (o), *Feronia limonia* (o), *Mallotus philippensis* (f), *Strychnos* sp. (f), *Callicarpa arborea* (la), etc.

IIa. No bamboo.

III. *Clerodendrum viscosum* (a), *Helicteres* (f), *Glycosmis* (la).

V. *Calycopteris* (a), *Acacia intsia* (f), *Wagatea* (f).

NOTE.—The evergreen undergrowth extending from damp spots includes *Actinodaphne*, *Psychotria*, *Webera*, *Ixora* and *Strobilanthes* spp. The most degenerate parts with either very shallow soil or hard vescicular laterite are definitely of a dry deciduous type, and appear unlikely to improve in any reasonable period of time.

(ii) *Kannoth, Kerala* (CHANDRASEKHARAN)—

I. *Terminalia paniculata**, *Xylia xylocarpa**, *Grewia tiliaefolia*, *Salmalia malabarica*, *Dalbergia sissoides*, *Terminalia bellerica*, *T. tomentosa*, *Albizzia odoratissima*, *Artocarpus hirsuta**, *Hopea parviflora*, *Teak* occurs very sporadically.

II. *Lannea coromandelica*, *Schleichera oleosa*, *Careya arborea*, *Dillenia pentagyna*, *Evodia lunu-ankenda*, *Erythrina* sp., *Gmelina arborea*, *Wrightia tinctoria*.

IIa. *Bambusa arundinacea*.

III. *Glycosmis pentaphylla*, *Helicteres isora*, *Desmodium* sp., *Leea indica*.

(iii) *Nilambur, Kerala*—

I. *Terminalia paniculata**, *Xylia xylocarpa*, *Lagerstroemia lanceolata**, *Terminalia tomentosa*, *Tectona grandis*, *Dalbergia latifolia*, *Grewia tiliaefolia*, *Adina cordifolia*, *Pterocarpus marsupium*, *Anogeissus latifolia*, *Tetrameles nudiflora*, *Canarium strictum*, etc.

II. *Dillenia pentagyna*, *Careya arborea*, *Trewia nudiflora*, *Mallotus philippensis*, *Ficus* sp., etc.

IIa. *Bambusa arundinacea*, *Oxytenanthera monostigma*.

III. *Clerodendrum viscosum*, *Helicteres isora*, *Glycosmis pentaphylla*, etc.

Sub-group 3C. North Indian Tropical Moist Deciduous Forests

1. NOMENCLATURE

Uttar Pradesh	Moist sal forest (CHAMPION). Sub-deciduous forest (in part) (OSMASTON). Monsoon forest (in part) (DUDGEON and KENOYER). *Bauhinia* forest (KENOYER).
Bihar	Moist peninsular sal forest (CHAMPION). Moist mixed forest. *Terminalia* formation (HAINES).
Orissa	Moist peninsular sal forest (CHAMPION). Coastal sal forest (CHAMPION, part).
West Bengal	Wet sal forest (CHAMPION, part). *Shorea-Stereospermum* associaton (COWAN). *Schima-Bauhinia* association (COWAN). Dry mixed forests (N. Bengal Working Plans). Plateau forests (N. Bengal Working Plans). River forests (part) (N. Bengal Working Plans). Open deciduous forests of S. Bengal. (COWAN).
Assam	Wet sal forest (CHAMPION, part). Kamrup alluvial sal forests (CHAMPION). *Terminalia-Morus* association (ROWBOTHAM). *Lagerstroemia-Terminalia* association (ROWBOTHAM).
Madhya Pradesh	Moist peninsular sal forests (CHAMPION).

2. GENERAL DESCRIPTION

The forests included under this type fall into two categories, sal forests, and the rest. The latter have to all intents and purposes been adequately described for the southern counter-part on pp. 118-120 Cold seems to prolong the leafless season, but otherwise the northern and southern moist mixed deciduous forests are very similar in all respects, the south having a slightly more varied flora as expected and more varied transitions to the evergreen and semi-evergreen types which are so much better represented there.

The sal forests have a facies of their own which is due to the undisputed pre-dominance of the one gregarious species. This dominance has unquestionably been intensified by human activities wherever the population has been dense enough to press on the forest. Sal is very generally more aggressive than any of its associates and competitors in natural gregarious habit, coppicing power, resistance to burning, regeneration under burning and grazing, adaptability to soil and site conditions, and longevity; though it suffers from frost, it survives it where few other species could. Planned forest management has intensified its dominance in many areas by selective removal of other competing species, but has unintentionally resulted in progression to semi-evergreen and evergreen types where the sal forest was of secondary origin and only a stable pre-climax with frequent burning. The sal typically forms high forest in which it constitutes 60 to 90 per cent of the top canopy which is 25—40 m. high and in undisturbed forest, fairly close and regular. A feature of sal which is important is its semi-evergreen habit with a deciduous period of only 5—15 days at the beginning of the hot weather. The shade from the new foliage keeps the sal forests cool in striking contrast to the fully deciduous forests adjoining, a feature particularly marked in peninsular India. The sal forest having a denser top canopy tends to have less middle canopy than the rest of the type and suppressed sal is often an important constituent. A shrubby undergrowth is usual, the shrubs being mostly semi-evergreen, and burning replaces them by grass the more easily the drier the locality. Climbers are few in species but include several large and common species which festoon the crowns particularly in open burnt localities. Canes occur only as a fringe along swampy streams. Bamboo is typically absent but may be present on dry or wet sites especially in open crops; only 2 or 3 species occur.

3. DISTRIBUTION

Moist deciduous forests occur throughout northern India except in the dry North-West and much of the over-wet East (North Bengal and Assam) though in the latter the type occurs in the primary succession on alluvial soils and in the former may occasionally be met with in favoured spots usually as a post climax. The type is therefore important to Uttar Pradesh, Bihar, Orissa, Madhya Pradesh, Bengal and Assam, and constitutes in fact their most important forests.

4. LOCALITY FACTORS

Temperature.—The mean annual temperature typically lies between 21° C and 26° C, as for the southern form. The January mean varies from 13° to 21° C, being 3° or so colder than the average in the south. The mean minimum is between 10° and 13° C. Whilst the winter may be definitely cold, frost is normally absent or unimportant.

Temperature
Northern Tropical Moist

Month	U.P. DEHRA DUN 682 m.			U.P. GORAKHPUR 77 m.			Orissa ANGUL 139 m.			Bihar CHAIBASA 226 m.		
	Mean	Mean max.	Mean min.	Mean	Mean max.	Mean min.	Mean	Mean max.	Mean min.	Mean	Mean max.	Mean min.
January . .	12·8	19·0	6·7	16·0	22·8	9·2	20·6	27·7	13·4	26·2	18·8	11·3
February .	14·4	20·7	8·1	18·3	25·4	11·2	23·4	30·4	16·3	28·8	21·4	14·1
March . .	19·3	26·3	12·3	24·3	32·2	16·3	27·8	35·4	20·1	34·6	26·7	18·8
April . .	24·6	32·2	16·9	29·6	37·4	21·8	31·5	38·9	24·1	38·9	31·3	23·7
May . .	28·4	35·6	21·2	31·7	38·4	24·9	32·9	39·7	26·1	40·0	33·1	26·2
June . .	28·8	34·3	23·4	31·2	36·1	26·2	30·8	35·5	26·1	36·1	31·2	26·2
July . .	26·7	30·1	23·2	29·4	32·7	26·2	28·2	31·2	25·1	31·9	28·6	25·3
August . .	25·9	29·0	22·7	29·4	32·7	26·2	27·9	30·9	24·9	31·3	28·1	24·9
September .	25·1	29·4	20·8	28·8	32·4	25·1	28·2	31·6	[illegible]4·7	30·3	27·4	24·4
October .	22·0	28·3	15·7	26·3	31·7	20·8	26·7	31·4	22·0	31·2	26·2	21·2
November .	17·5	24·3	10·6	20·9	27·8	14·1	22·8	28·8	16·8	28·3	21·8	15·4
December .	14·9	20·6	7·3	16·8	23·6	9·9	19·7	26·7	12·8	25·6	18·3	10·9
M. A. T. .	21·6	..	..	25·7	..	..	26·7	..	..	26·1	..	..
Annual mean maximum .	27·5	..	..	32·1	..	..	32·4	..	..	32·1	..	..
Highest record .	43·9	..	..	46·1	..	..	46·1	..	..	46·1	..	..
Annual mean minimum .	15·7	..	..	19·3	..	..	21·1	..	..	20·2	..	..
Lowest record .	—1·1	..	..	1·7	..	..	6·7	..	..	4·4	..	..
No. of years .	60 (to 1940)	..	..	60 (to 1940)	..	..	45	..	..	30	..	..

(*centigrade*)
Deciduous Forest

Month	West Bengal JALPAIGURI 83 m.			M.P. RAIPUR 296 m.			Assam GAUHATI 55 m.			Manipur IMPHAL 792 m.		
	Mean	Mean max.	Mean min.	Mean	Mean max.	Mean min.	Mean	Mean max.	Mean min.	Mean	Mean max.	Mean min.
January .	17·1	23·6	10·6	20·4	27·6	13·2	17·1	23·7	10·6	12·4	21·6	3·3
February .	18·6	24·9	12·1	22·3	30·0	14·5	18·8	25·6	12·1	14·1	23·7	4·4
March . .	22·7	29·6	15·7	27·6	35·1	20·0	22·8	29·9	15·7	18·9	27·1	10·8
April . .	26·0	31·9	20·1	32·0	39·3	24·6	26·2	31·2	21·2	20·3	27·0	13·6
May . .	27·3	31·9	22·6	34·8	41·8	27·8	26·7	30·9	22·4	24·3	28·7	19·9
June . .	27·9	31·4	24·3	31·4	36·6	26·2	28·2	31·6	24·7	24·9	28·6	21·1
July . .	28·3	31·4	25·2	27·2	30·4	23·9	28·9	32·1	25·7	24·6	27·6	21·6
August . .	28·4	31·6	25·2	26·8	29·9	23·8	29·0	32·4	25·6	24·4	27·9	20·9
September .	27·8	31·2	24·4	27·6	31·2	23·9	28·2	31·8	24·6	24·7	29·2	20·2
October .	25·8	30·4	21·3	26·2	31·4	20·9	26·1	30·6	21·7	23·1	28·6	17·4
November .	21·9	27·8	16·0	22·3	28·7	15·9	29·9	27·4	16·3	19·1	25·3	12·8
December .	18·3	24·8	11·8	19·6	26·7	12·5	17·9	24·3	11·5	12·2	21·5	2·8
M. A. T. .	23·9	..	..	32·4	..	..	24·3	..	..	20·3	..	..
Annual mean Maximum .	29·2	..	..	47·2	..	..	29·3	..	..	26·4	..	..
Highest record .	40·0	..	..	20·7	..	..	40·0	..	..	?	..	..
Annual mean Minimum	19·1	..	..	3·9	..	..	19·3	..	..	14·1	..	..
Lowest record .	2·2	..	..	?	..	..	2·8	..	..	?	..	..
No. of years .	55 (to 1940)	..	..	60 (upto 1940)	..	..	45	..	..	? (upto 1955)	..	..

Rainfall and Humidity.—The minimum rainfall for the type is about 1,000 mm. but except on favourable sites at least 1,300 mm. is usual. The upper limit is about 2,000 mm. but the type may be developed with much heavier falls on rapidly draining sites (N. Bengal and U. Bhabar) or shallow soils (generally), or as a pre-climax with burning (Bengal and Assam).

In the N. W., there is a period lasting seven months long with monthly rainfall less than 50 mm., humidity conditions improving eastwards till the type ceases to be the climatic climax when there are only 3 or 4 dry months. The following rainfall data are given for areas where the type is believed to be the climatic climax though as usual, the recording stations are rarely actually in the forest : the N. Bengal and Assam sub-Himalayan stations are exceptional and included only as representing important sub-climax sal forest tracts.

Rock and Soil.—A large part of the type occurs on the Indo-Gangetic alluvium, the sal tending to be restricted to the older levels whilst the non-sal forests occur throughout. Moist deciduous forest extends on to the Siwalik formations in the sub-Himalayan tract and foot-hills and on to older rocks south of the plains in the Central Provinces, Bihar and Orissa. The soil may be sandy or clayey, both extremes tending to be avoided by sal but being suitable for the other types provided it is reasonably deep and fertile; otherwise, dry deciduous forest replaces the sal when the soil is unfavourable in these respects. In peninsular India and parts of Assam, red tropical soils including lateritic soils carry this type of forest, the sal attaining its best development on well drained ferruginous soils.

Topography.—As noted, the type is extensively met with on the great plains of N. India but spreads over the Siwalik hills up on to the outer Himalayan slopes in the north and over the peninsular plateaux and low hills to the south, down to the northern borders of Andhra Pradesh, wherever the moisture and soil conditions are favourable.

5. GENERAL FLORISTICS

Just as *Tectona grandis* is the ecologically characteristic and economically important species of the southern moist deciduous forest, so *Shorea robusta* characterises the northern form. *Terminalias* form the most noticeable associates in both types and *Lagerstroemia* and *Pterocarpus* are likewise often prominent especially in the peninsular region. *Schleichera* and *Careya* are again frequent in the second storey but coriaceous evergreens are infrequent except for *Syzygium cumini; Mallotus philippensis* is characteristic of the alluvial sal forests in the western half of the range. Bamboos are absent over the greater part of the type but *Dendrocalamus strictus* is locally conspicuous and important; it is associated with miscellaneous forests devoid of sal rather than with the sal forests proper. *Bambusa arundinacea* is restricted to special damp sites. Certain shrubs and weeds such as *Mallotus, Clerodendrum viscosum, Pogostemon, Murraya koenigii* may occur gregariously in the undergrowth. *Bauhinia vahlii* is a common climber. Grasses become important both in the seral stages and under the influence of fire, and a grass undergrowth is usual though with fire protection it tends to be eliminated.

Rainfall (millimetres)

Northern Tropical Moist Deciduous Forest

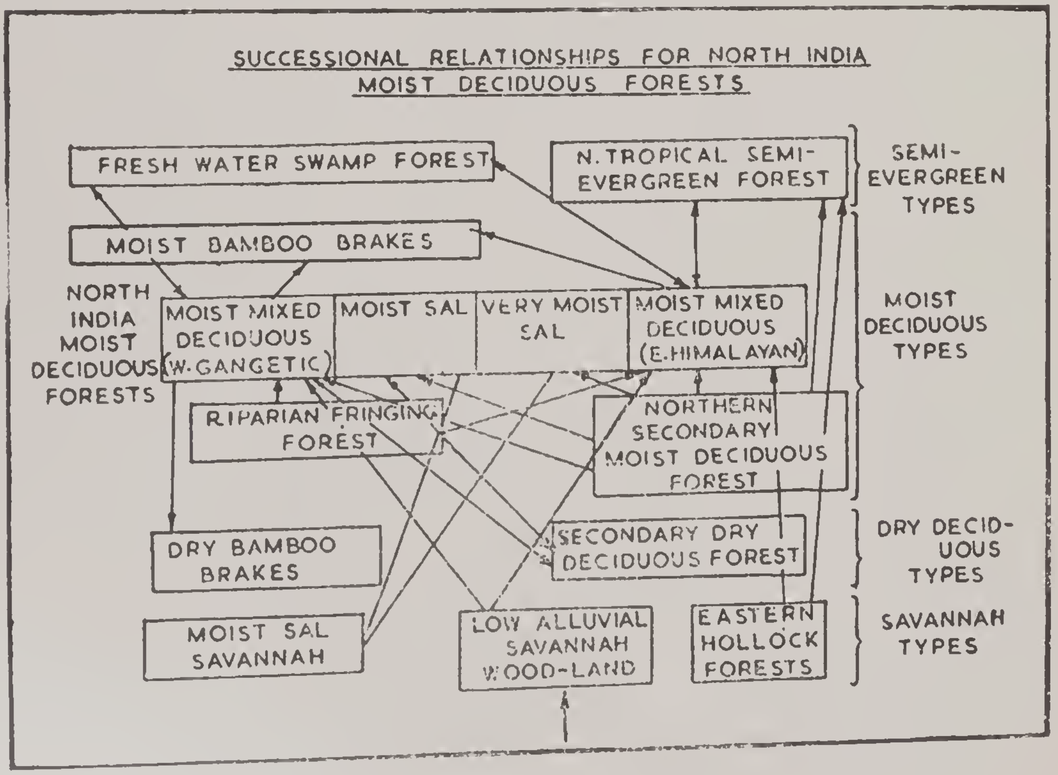
Month	U.P.	U.P.	U.P.	Orissa	Bihar	Bihar	M.P.	M.P.	Assam	Bengal	Assam	Assam	Mani-pur
	Dehra Dun	Kheri	Gorakhpur	Angul	Goilkera	Chaibasa	Raipur	Balaghat	Gauhati	Jalpaiguri	Kochugaon	Golaghat	Imphal
	682 m.	140 m.	77 m.	139 m.	320 m.	226 m.	296 m.	308 m.	55 m.	83 m.	71 m.	96 m.	792 m.
	Rainfall mm.	Rainfall mm.	Rainfall mm.	Rainfall mm.	Rainfall mm.	Rainfall mm.	Rainfall mm.	Rainfall mm.	Rainfall mm.	Rainfall mm.	Rainfall mm.	Rainfall mm.	Rainfall mm.
January . .	59	22	15	11	18	16	9	13	10	8	12	23	13
February . .	63	22	16	29	37	38	22	21	30	17	25	39	44
March . .	32	13	10	19	22	22	18	15	51	32	53	85	84
April . .	17	7	9	26	21	27	16	15	145	94	225	189	125
May . .	37	31	35	60	52	70	23	17	236	300	466	243	151
June . .	217	158	192	217	239	198	230	241	312	659	940	294	249
July . .	668	308	346	317	465	333	381	561	312	818	861	354	262
August . .	731	313	349	294	424	311	364	458	261	642	566	332	238
September .	270	196	216	187	220	201	195	234	167	539	590	240	148
October . .	32	38	75	100	88	74	55	52	71	141	164	100	105
November . .	9	6	5	28	13	18	14	15	14	13	14	21	41
December . .	26	10	5	4	6	5	5	6	4	4	6	11	12
Total for year (March) . .	2,160	1,120	1,274	1,290	1,603	1,312	1,332	1,646	1,612	3,267	4,020	1,931	1,474
No. of rainy days .	81	48	57	72	76	74	64	73	89	108	112	114	103
No. of month less than 50 . .	6	8	7	6	6	6	7	7	4	5	4	4	4
M.A.H. . .	61		64	63	?	66	57	?	77	71	?	?	?
No. of years .	?	73	?	35	45	50	?	74	?	35	54	?	?

6. SUB-DIVISIONS, SUCCESSIONS, ETC.

The representative form is taken to be sal forest with slightly different variations in hills and plains. The sal forest is, however, broken up by more pronouncedly deciduous forests which usually appear to owe their presence to less-favourable soil conditions especially as regards moisture, and sal is absent locally in S. Bengal with deciduous forest predominating in its place, notably on young alluvium. These edaphic associations may be of either pre-climax or post-climax status. Bamboo brakes occur but are usually of limited extent, whilst such cane brakes as occur are strictly restricted to permanently wet sites.

The primary seral stages on new alluvium are perhaps the best known in India. New gravels are colonised by the *Khair-sissu* association (p. 222) which leads on through several recognisable mixed deciduous forms as the soil is built up, and finally becomes suitable for the climax sal forest. At any stage, clearing, fellings, fire and grazing may lead to a secondary savannah (p. 146) which may persist indefinitely. The following sub-types are recognised :

C1. Very moist sal-bearing forest.
C2. Moist sal-bearing forest.
DS1. Moist sal savannah.
C3. Moist mixed deciduous forest.
2S1. Northern secondary moist mixed deciduous forest.
2S2. Secondary Euphorbiaceous scrub.


SUCCESSIONAL RELATIONSHIPS FOR NORTH INDIA MOIST DECIDUOUS FORESTS
FRESH WATER SWAMP FOREST
N. TROPICAL SEMI-EVERGREEN FOREST
SEMI-EVERGREEN TYPES
MOIST BAMBOO BRAKES
NORTH INDIA MOIST DECIDUOUS FORESTS
MOIST MIXED DECIDUOUS (W. GANGETIC)
MOIST SAL
VERY MOIST SAL
MOIST MIXED DECIDUOUS (E. HIMALAYAN)
MOIST DECIDUOUS TYPES
RIPARIAN FRINGING FOREST
NORTHERN SECONDARY MOIST DECIDUOUS FOREST
DRY BAMBOO BRAKES
SECONDARY DRY DECIDUOUS FOREST
DRY DECIDUOUS TYPES
MOIST SAL SAVANNAH
LOW ALLUVIAL SAVANNAH WOOD-LAND
EASTERN HOLLOCK FORESTS
SAVANNAH TYPES

C1. Very moist sal-bearing forest

DESCRIPTION.—The general appearance and composition of the main canopy are indistinguishable from those of the moist sal forest. *Shorea robusta* remains the gregarious dominant and the associated species are practically the same: there is a similar range of quality with height over 40 m. on the best sites to under 25 m. on the poorer sites with annual burning. The undergrowth is also very closely similar in appearance and composition, consisting mostly of shrubs under a closed canopy; grass comes in and spreads rapidly wherever the canopy is at all broken. With protection, an evergreen lower storey and shrub growth is rapidly redeveloped.

The general description given on p.121 above is applicable as long as periodic fires sweep through. Hollows and stream-sides carry a much richer evergreen vegetation which rapidly spreads with fire protection, particularly monocotyledonous herbs such as *Alpinia*. The associates of the sal are like itself markedly fire-hardy.

In the peninsular subtype, the sal is rather more mixed with miscellaneous species, and the undergrowth includes more (and more varied) evergreen small trees and shrubs than in the *Moist sal*. Bamboos are more general. Grass is present where the forest is burnt but is mostly displaced by evergreens with fire protection. Climbers are heavy.

The following subtypes are recognised :

- Cla. Eastern hill sal forest
    - (i) East Himalayan sal
    - (ii) Khasi hill sal
- Clb. Eastern *bhabar* sal forest
    - (i) East Himalayan upper *bhabar* sal
    - (ii) East Himalayan lower *bhabar* sal
- Clc. Eastern *tarai* sal forest
- Cld. Peninsular (coastal) sal forest.

DISTRIBUTION.—The type occurs throughout the E. Sub-Himalayan *bhabar-tarai* and plains tract including the lower slopes of the Himalayas and the Garo, Khasi, Mikir and Jaintia hills of Assam south of the Brahmaputra. (E. Nepal, Bengal, Bhutan and Lower Assam). The coastal sal of Angul and Puri in Orissa is the peninsular counterpart.

LOCALITY FACTORS.—The rainfall is typically high along the foot of the Himalayas from 2,000 mm. upwards to 5,000 mm. or more. The data for Jalpaiguri and Kochugaon illustrate fairly representative conditions. In Kamrup (Assam) it is 1,800 to 2,300 mm. with a rather more even distribution as indicated by figures for Gauhati. In the peninsular region, the rainfall is around 1,900 mm. but the special feature is the higher relative humidity associated with a coastal climate, i.e. over 70 for the year and about 70 for March, as against lower values (60—70 and 65 respectively) for the rest of the tract. There are not more than 4 months with less than 50 mm. rain.

TOPOGRAPHY AND SOILS.—The type occurs on lower foothills, undulating areas and on gently sloping to flat alluvial deposits.

The soil in the lower hills and upper bhabar tract varies considerably, the S. Assam forest providing examples of typical red tropical soils on crystalline rocks, the sub-Himalayan forest being all on post-tertiary alluvium and the Himalayas providing examples of metamorphic rocks of various kinds and ages. The forests may be on steep well-drained slopes with high rainfall, or on low lying alluvium with permanently high water table. In the lower *bhabar*, *tarai*, and plains portion, the soil is entirely alluvial grading from coarse, with gravel and boulder, to fine and humified and often red on old alluvium. There is extensive development of the type on flat ground but no separate "plains" type has been distinguished owing to the uncertainty as to the status of the few apparent remnants. The very moist peninsular (coastal) sal occurs on soil derived from schists and gneisses which is commonly red and in places lateritic.

C1a. Eastern hill sal forest

This subtype is characterised by the prevalence of *Dendrocalamus hamiltonii* and dense undergrowth. The site quality is I-III, and it occurs on many different rocks. The chief associates are :—

I. *Schima wallichii.*
IIa. *Dendrocalamus hamiltonii.*
IVb. *Microstegium ciliatum, Imperata arundinacea.*

Regeneration is difficult with *Microstegium* but is fair otherwise. Two variations are conveniently differentiated, *viz.*

C1a(i). E. Himalayan sal

Sal is restricted to ridges with well drained soils on Nahan sandstone. The site quality is typically II. Characteristic species are :

I. *Schima wallichii, Stereospermum personatum.*
IIa. *Dendrocalamus hamiltonii.*
III. *Desmodium* spp.
IVb. Light *Imperata cylindrica.*

Regeneration of sal is satisfactory.

FLORISTICS.—

(i) *Teesta valley slopes, Kurseong Division, West Bengal.* (After COWAN).—

I. *Shorea robusta** (34·4%), *Garuga pinnata** (7·1%), *Terminalia belerica** (50·0%), *T. tomentosa* (4·1%), *Schima wallichii* (2·8%), *Lagerstroemia parviflora* (2·7%), *Tetrameles nudiflora* (2·6%), *Sterculia villosa* (2·6%), *Stereospermum personatum* (2·1%), *Cedrela* spp. (2·1%), *Bauhinia purpurea* (2·0%).
II. *Mallotus philippensis, Callicarpa arborea, Litsea monopetala, Semecarpus anacardium, Symplocos laurina.*
IIa. *Dendrocalamus hamiltonii* (local).
III. *Leea* sp., *Indigofera pulchella.*
IV. *Microstegium ciliatum* (la).
V. *Aspidocarya unifera, Bauhinia vahlii, Beaumontia grandiflora, Buettneria pilosa, Millettia auriculata.*

NOTE.—This is COWAN's *Shorea-Terminalia-Garuga* association. It is not known how far burning and other biotic factors have influenced the present occurrence of the type and it seems likely that with protection, an appreciable proportion may progress to semi-evergreen or evergreen forest, but part at least is likely to persist as a true climax.

(ii) *Kurseong Division, W. Bengal.* Preservation Plot No. 21, 650 m; 3800 mm. rainfall.

I. *Shorea robusta**, *Schima wallichii** (f), *Terminalia tomentosa* (f), *T. bellerica, Sterculia villosa, Chukrasia tabularis, Cedrela microcarpa, Syzygium cumini, Litsea monopetala, Ficus indica, Castanopsis tribuloides, Canarium sikkimense, Aphanamixis polystachya.*

II. *Ilex godajam, Aporosa roxburghii, Phoebe lanceolata, Castanopsis indica, Sarcosperma arboreum, Firmiana colorata, Heynea trijuga, Garuga pinnata, Helicia erratica, Mallotus philippensis, Emblica officinalis, Quercus lanceaefolia, Caryota urens, Machilus glaucescens, Baccaurea sapida, Quercus spicata, Bauhinia purpurea, Grewia vestita, Bridelia retusa* etc.

IIa. *Dendrocalamus hamiltonii* (a).

III. Light. *Tephrosia candida, Leea crispa, Desmodium floribundum, D. tiliaefolium, Clerodendrum viscosum, Morinda tinctoria.*

IVa. *Alpinia allughas.*

IVb. *Setaria plamifolia, Microstegium ciliatum.*

V. *Piper* spp.

(iii) *Outer Himalayan slopes, Kalimpong Division, W. Bengal* (COWAN).—

I. *Shorea robusta** (13·3), *Stereospermum personatum** (9·7), *Terminalia crenulata* (9·1), *Schima wallichii** (4·3), *Bauhinia purpurea* (3·5), *Dillenia pentagyna* (3·2), *Sterculia villosa* (2·5), *Talauma hodgsoni* (2·3), *Garuga pinnata* (2·2), *Albizzia* spp. (2·1).

II. *Meliosma simplicifolia, Grewia vestita, Eugenia* spp., *Styrax* spp., *Engelhardtia spicata.*

IIa. *Dendrocalamus hamiltonii**.

NOTE.—This is COWAN's *Shorea-Stereospermum* climax association which he notes as occurring on the Nahan sandstone and as decidedly more xerophilous than the last. The much lower percentage of sal is characteristic and the form is evidently an edaphic variant on the last with features approximating the non-sal moist deciduous forest.

(iv) *Rangit Valley, W. Bengal.*—

I. *Shorea robusta** (70%), *Pinus roxburghii* (30%).

II. *Schima wallichii**, *Semecarpus anacardium, Phoebe lanceolata, Syzygium cumini, Casearia graveolens, Bridelia retusa.*

III. *Wendlandia tinctoria, Woodfordia fruticosa, Indigofera* spp., *Moghania* spp, *Phoenix.*

IVb. *Microstegium ciliatum, Thysanolaena maxima.*

NOTE.—This is an ecotone to the Siwalik chir pine type.

C1a(ii). Khasi hill sal

This type occurs on the upper portions of the Khasi foot hills, 150 to 650 m. on soils derived from gneiss, quartzite or conglomerate. The soils are gravelly on crests and upper slopes, deep red and clayey in the foot hills and alluvial lower down. Sal occurs in pure crops among mixed deciduous species, mainly on the ridges. Typical site quality is III-II. Dense *Microstegium ciliatum* is the most usual ground cover. Regeneration of sal is very inadequate and difficult to induce. Characteristic associates are :

I. *Schima wallichii*, *Adina cordifolia*.
II. *Premna* spp.
IIa. *Dendrocalamus hamiltonii**.
IVb. Heavy *Microstegium ciliatum*, *Imperata cylindrica*.

FLORISTICS.—

(i) *Kamrup Division, Assam.*—

I. *Shorea robusta** (va), *Schima wallichii** (f), *Adina cordifolia** (f), *Gmelina arborea* (lf), *Lagerstroemia parviflora* (o), *Dillenia pentagyna* (f), *Vitex peduncularis* (o), *Terminalia bellerica* (o).

II. *Emblica officinalis* (lf), *Premna latifolia** (f), *Aporosa roxburghii* (f), *Aphanamixis polystachya* (la), *Garcinia* sp., *Careya arborea*.

IIa. *Dendrocalamus hamiltonii** (la).

III. *Desmodium* spp., *Eupatorium odoratum*, *Zizyphus mauratiana*.

IVa. *Microstegium ciliatum*, *Imperata cylindrica*, *Thyanolaena maxima*, *Carex stroemenfilia*.

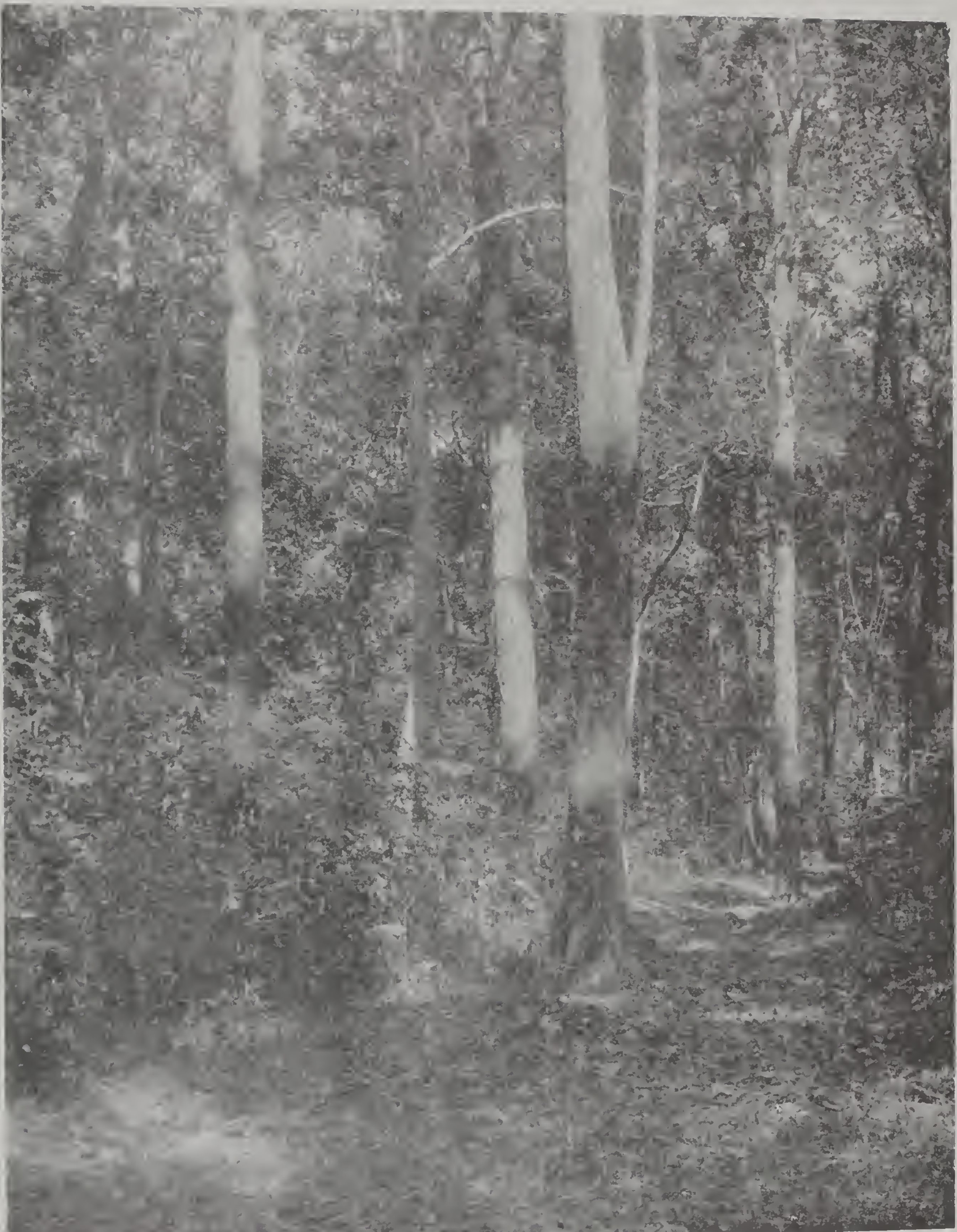
V. *Zizyphus oenoplia*, *Entada phaseoloides*, *Butea parviflora*.

NOTE.—In hollows *Dendrocalamus hamiltonii* occurs profusely and occasional, *Artocarpus chaplasha*, *Michelia champaca* and *Amoora spectabilis* are also found. *Carex* spp. occur under dense canopy.

At the lower elevations of 80 to 150 m., the sal occurs in mixture with *Schima*, *Dillenia*, *Vitex* etc. and *Premna*, *Phoebe*, *Lauraceae* and *Dendrocalamus hamiltonii* form a dense middle canopy. The undergrowth consists of *Microstegium*, *Coffea bengalensis* and *Alpinia*.

On colluvium and older alluvium hillocks and deposits, there is no middle canopy except the bamboo and the undergrowth may include *Aporosa obliqua*, *Sterculia villosa*, and *Dillenia*. The ground flora consists of *Alpinia*, *Coffea*, *Carex*, *Eupatorium* and *Microstegium*. Climbers are scarce (*Butea parviflora*, *Vitis palmata*).

GENERAL NOTE.—This subtype is closely allied to Himalayan forms and probably represents a true climax though its territory has been artificially extended by past burning and jhuming and is again being reduced by fire protection. At its upper limit at 650 m., *Schima* largely replaces sal.



VERY MOIST BHABAR SAL FOREST

Shorea robusta with *Schima wallichii*, *Dillenia pentagyna*, *Terminalia bellerica* (centre) and evergreen undergrowth of *Amoora*, *Leea*, *Coffea*, *Ervatamia* etc.

Jainti, Buxa Division, West Bengal.

H. G. Champion

C1b. Eastern bhabar sal forest

High quality sal. Typical site quality is II-I, on alluvial loamy soil. Regeneration of sal is impossible with fire protection. The characteristic associates are :—

I. *Schima wallichii, Lagerstroemia parviflora, Terminalia tomentosa.*

II. *Lauraceae, Meliaceae.*

IVb. *Imperata cylindrica, Microstegium ciliatum.*

C1b(i). East Himalayan upper bhabar sal

This subtype is characterised by the presence of dense *Microstegium ciliatum.* It occurs on alluvial, well drained soil with boulders. If the forest is burnt regularly some regeneration takes place but only very slowly. The sal is of Qty. I-II. The characteristic associates are :—

I. *Lagerstroemia parviflora.*

II. *Aphanamixis polystachya.*

IVb. *Microstegium ciliatum.*

ILLUSTRATION.—Plate 23.

FLORISTICS.—

(i) *Kurseong Divn., W. Bengal.* 300 m.; 3800 mm. rainfall. Preservation Plot No. 22.—

I. *Shorea robusta** (va), Scattered *Terminalia tomentosa, Duabanga grandiflora, Cedrela microcarpa, Tetrameles nudiflora, Elaeocarpus aristatus, Lagerstroemia parviflora*, Canarium sikkimense, Amoora wallichii, Aphanamixis polystachya*, Sterculia villosa, Salmalia malabarica, Engelhardtia spicata, Chukrasia tabularis, Anthocephalus indicus, Gmelina arborea, Terminalia bellerica, Albizzia marginata, Stereospermum personatum, Turpinia pomifera, Litsaea monopetala.*

II. Scattered *Spondias pinnata, Artocarpus lakoocha, Heynea trijuga, Callicarpa arborea, Premna integrifolia, Garuga pinnata, Bauhinia purpurea, Emblica officinalis, Phoebe lanceolata, Alangium chinense, Aporosa roxburghii, Morus laevigata, Mallotus roxburghiana, Macaranga denticulata, Ficus glomerata, Syzygium cumini, Oroxylum indicum, Ilex godajam, Vitex quinata, Dillenia pentagyna, Careya arborea.*

IIa. *Dendrocalamus hamiltonii* (va).

III. Dense *Clerodendrum viscosum, Morinda tinctoria, Leea crispa, Boehmeria macrophylla, Coffea bengalensis.*

IVa. Ferns, *Girardinia heterophylla.*

IVb. *Microstegium ciliatum.*

(ii) *Buxa Division, W. Bengal.* Linear Increment Plot No. 2.—

I. *Shorea robusta** (va), *Schima wallichii** (f), *Lagerstroemia parviflora** (f), *Dillenia pentagyna* (f), *Terminalia bellerica* (f), *Sterculia villosa* (o), *Stereospermum personatum* (o), *Lannea coromandelica* (o), *Garuga pinnata* (o), *Gmelina arborea* (o), *Bridelia retusa* (o), *Cedrela toona* (o).

II. *Aphanamixis polystachya** (E) (f), *Premna integrifolia* (f), *Mallotus philippensis* (f), *Eugenia* spp. (f), *Machilus* sp. (f), *Wrightia tomentosa* (o), *Fagara budrunga* (o), *Careya arborea* (o).

(iii) *Ripu, Goalpara West Division, Assam.* (RAJKHOWA)—

I. *Shorea robusta** (va), *Dillenia pentagyna* (3%), *Schima wallichii** (1·6%), *Sterculia villosa* (1·4%), *Stereospermum personatum* (1·1%), *Lagerstroemia parviflora** (1%), *Lannea coromandelica, Terminalia bellerica, Gmelina arborea, Vitex peduncularis, Amoora wallichii* and occasional *Albizzia* spp., *Salmalia, Alstonia, Cedrela, Tetrameles* etc.

II. *Premna* spp., *Wrightia tomentosa, Careya arborea, Dillenia, Bridelia.*

III. *Eupatorium odoratum* (plantations), *Coffea bengalensis, Clerodendrum viscosum, Leea, Moghania.*

IVb. *Microstegium ciliatum, Imperata cylindrica* (with burning).

Percentages indicate proportions of associates over 60 cm. girth, taking sal as 100.

(iv) *Bamba, Goalpara West Division, Assam.* (RAJKHOWA).—

I. *Shorea robusta** (va), *Stereospermum personatum* (7%), *Schima wallichii** (6%), *Terminalia bellerica* (6%), *Dillenia pentagyna* (4%), *Lagerstroemia parviflora** (4%), *Gmelina arborea* (3%), *Lannea coromandelica* (2%), *Garuga pinnata* (2%), *Sterculia villosa* (2%), *Salmalia, Syzygium cumini, Vitex peduncularis, Aphanamixis polystachya**, *Cedrela toona, Litsea monopetala, Phoebe goalparensis* etc.

II. *Dillenia pentagyna, Careya arborea, Callicarpa arborea, Albizzia* spp.

III. *Coffea bengalensis, Clerodendrum viscosum, Litsea* sp. and *Eupatorium odoratum* (in regeneration areas).

IVb. *Microstegium ciliatum.*

V. *Vitis latifolia, Millettia auriculata, Dalbergia stipulata.*

Percentages indicate proportion of associates over 60 cm. girth, taking sal as 100.

ILLUSTRATION.—CHAMPION (1933); Plate 22.

NOTE.—This was previously distinguished as the Bamba subtype (D2a). The percentage of fire tender evergreens is somewhat higher, otherwise there is no difference from the typical examples.

C1b(ii). East Himalayan lower bhabar sal

This subtype differs from the upper bhabar subtype in being decidedly damper with *Microstegium* less in evidence and with *Terminalia tomentosa*, *Machilus* spp., and more *Meliaceous* trees. It is a tall forest with high quality sal. Regeneration is impossible with fire protection as a dense evergreen undergrowth whereas the *Imperata* increases with burning. The quality is I-II on alluvial, well drained, but not bouldery soil. The characteristic associates are:—

I. *Terminalia tomentosa.*

II. *Machilus* spp., *Meliaceae.*

ILLUSTRATION.—CHAMPION (1933); Plate 23.

FLORISTICS.—

(i) *Bamanpokhri, West Bengal.* 260 m. upwards.—

I. *Shorea robusta*, Terminalia tomentosa*, Schima wallichii*, Terminalia bellerica, Dillenia, Lagerstroemia parviflora*, Sterculia villosa.*

II. *Wrightia tomentosa, Grewia vestita, Premna, Macaranga,* etc.

III. *Clerodendrum viscosum, Coffea bengalensis, Phlogacanthus.*

(ii) *Buxa Division, W. Bengal.* Preservation Plot No. 3.—

I. *Shorea robusta*, Sterculia villosa, Lagerstroemia parviflora*, Schima wallichii*, Salmalia malabarica, Cassia fistula, Albizzia odoratissima.*

II. *Oroxylum indicum, Careya arborea, Dillenia pentagyna, Premna integrifolia, Glochidron acuminatum, Mallotus philippensis, Bridelia retusa, Garuga pinnata, Emblica officinalis, Drypetes lancifolia* etc.

III. *Coffea bengalensis, Clerodendrum viscosum* etc.

IVa. *Leea crispa, Alpinia speciosa.*

IVb. *Saccharum* spp., *Microstegium ciliatum.*

V. *Millettia, Mucuna prurita, Cissus repanda, Vitis* sp., *Dalbergia stipulacea.*

(iii) *Jalpaiguri Division, West Bengal.*—

I. *Shorea robusta* (va), *Terminalia bellerica* (o), *T.tomentosa** (o), *Dillenia pentagyna* (o).

II. *Careya arborea, Premna bengalensis, Premna integrifolia, Amoora wallichii*, Aphanamixis polystachya*, Lagerstroemia parviflora, Aporosa dioica, Holarrhena antidysenterica, Macaranga denticulata, Mallotus roxburghii, Meliosma simplicifolia.*

III. *Coffea bengalensis* (f), *Clerodendrum viscosum* (lf).

IVa. *Alpinia allughas* (va), *Leea crispa* (f), Ferns.

IV. No grass (*Imperata* with burning).

V. *Millettia auriculata, Dalbergia stipulacea, Tinospora cordifolia, Acacia* sp., *Vitis* sp.

NOTE.—S. P. 1 & P.P. 3, Jalpaiguri Division, on which the above floristics are based represent some of the finest sal growth.

(iv) *Goalpara West Division, Assam.*—

I/II. *Shorea robusta, Terminalia bellerica, Lagerstroemia parviflora*, Schima wallichii*, Stereospermum personatum, Dillenia pentagyna, Gmelina arborea, Lannea coromandelica, Garuga pinnata, Vitex peduncularis.*

C1c. Eastern tarai sal forest

This subtype is characterised by the presence of canes and ferns, without bamboo, and occurs on dark alluvium and *khurkhani* soil with a wet subsoil. The sal is of Q. C. III-II and regeneration is impossible with fire protection. *Michelia champaca, Castanopsis* and mixed evergreens, and *Themeda* and other large grasses in place of *Microstegium.*

The characteristic associates are :—

I. *Michelia champaca, Castanopsis.*

II. *Machilus* spp., Mixed evergreens.

IVb. *Themeda arundinacea* etc., with burning.

ILLUSTRATION.—CHAMPION (1933); Plate 24.

FLORISTICS.—

(i) *Linear S. P. Nos. 1 and 3, Buxa Division (West Bengal).*—

I. *Shorea robusta** (va) (16·8%), *Elaeocarpus varunna* (8·9%), *Machilus villosa** (f) (5·5%), *Stereospermum personatum* (f) (5·3%), *Schima wallichii* (f) (4·3%), *Terminalia bellerica* (lc) (1·4%), *Lagerstroemia parviflora* (lc) (1·0%).

II. *Meliosma simplicifolia* (a) (11·3%), *Aphanamixis polystachya* (7·5%), *Premna bengalensis* (f) (2·6%), *Bauhinia purpurea* (lc)(1·9%), *Turpinia pomifera* (lc) (1·7%), *Saurauja roxburghii* (lc) (1·2%).

NOTE.—Unquestionably a seral stage to evergreen forest.

(ii) *Goalpara West Division, Assam* (RAJKHOWA).—

I. *Shorea robusta** (va), *Schima wallichii* (4%), *Stereospermum personatum* (3%), *Dillenia pentagyna* (2%), *Terminalia bellerica* (2%), *Lagerstroemia parviflora* (1%), *Lannea coromandelica* (1%), *Eugenia* spp. (1%), *Sterculia villosa, Vitex peduncularis, Premna* spp., *Cedrela toona, Albizzia procera, Salmalia, Gmelina, Ilex godajam, Litsea monopetala, Phoebe goalparensis, Bridelia retusa, Amoora wallichii.*

II. *Turpinia pomifera, Talauma hodgsoni, Machilus villosa*.*

III. *Morinda angustifolia, Leea indica, Eupatorium odoratum* (open places).

IVa. *Alpinia allughas.*

IVb. *Microstegium ciliatum.*

Percentages indicate proportion of associates over 90 cm. girth, taking sal as 100.

VERY MOIST PENINSULAR (COASTAL) SAL FOREST

A coastal sal stand on Tamna hill, Puri Division, Orissa.

S. K. Seth

General Note.—There is a great deal of evidence that most of the type in the *tarai* and *bhabar* tracts owes its existence to periodic burning and locally to shifting cultivation, the sal having grown up in grass savannahs. It is equally evident that with fire protection it is progressing to a largely evergreen type from which sal will be almost entirely absent owing to its inability to regenerate under evergreen shade. Only in the upper part of the *bhabar* it is likely to be able to persist, cf. p. 131.

C1d. Peninsular (coastal) sal forest

ILLUSTRATION.—Plate 24.

FLORISTICS.—

I. *Shorea robusta** (50%), *Dillenia pentagyna*, *Terminalia tomentosa*, *Bridelia retusa*, *Adina cordifolia*.

II. *Syzygium cumini*, *Protium serratum*, *Polyalthia cerasoides** (E), *Cycas circinalis* (o).

IIa. *Bambusa arundinacea** (a), *Dendrocalamus strictus* (a), *Oxytenanthera* (lo).

III. *Rubiaceae* (*Webera*, *Psychotria*, etc.), *Ardisia solanacea*, *Leea* sp., *Macaranga peltata*, *Strobilanthes* spp.

IVb. *Thysanolaena*, *Imperata*, *Panicum* spp.

V. *Bauhinia vahlii*, *Combretum decandrum*, *Butea superba*, *Zizyphus oenoplia*.

Note.—Much of the area at present occupied by the type is unquestionably a stable subclimax type to semi-evergreen (cf. p.101) conditioned by burning. On the introduction of fire protection, progression rapidly commences with the establishment of a dense evergreen undergrowth including tree species. This fact would appear to indicate that parts of the sal forest may be of secondary origin, an edaphic climax occurring only on well drained ridges and slopes. It gradually merges with the moist peninsular type.

C2. Moist sal-bearing forest

DESCRIPTION.—The typical moist sal forest has already been described above on page 121. Owing to its importance it has been subdivided into a number of subtypes and forms, the most comprehensive analysis being by CHAMPION (1933). In the present work this classification has been revised in accordance with current ideas and the much more detailed information now available. The *Moist Sal* is viewed as a climax (climatic, edaphic or bio-edaphic) formation throughout and some forms which might be considered seral have also been included in the climax type as they are sufficiently stable under prevailing conditions of management. The main climatic features distinguishing the moist sal type are :—

Rainfall 1,400—1,900 mm. (1,300—2,500 mm). Mean daily relative humidity for the year 60—70, for March about 45—60.

The following subdivisions are recognised :—

C2a—Moist Siwalik sal
C2b—Moist bhabar sal
  (i) Bhabar-dun sal
  (ii) Damar sal
C2c—Moist tarai sal
C2d—Moist plains sal
  (i) Western light alluvium plains sal
  (ii) Eastern heavy alluvium plains sal
C2e—Moist peninsular sal
  (i) Moist peninsular high level sal
  (ii) Moist peninsular low level sal
  (iii) Moist peninsular valley sal

DISTRIBUTION.—That of type as a whole, being present in more or less varying form throughout northern India wherever rainfall is not less than 1,000 mm. Mixed deciduous forest without sal is locally present wherever the soil or other locality factors overstep the relatively narrow limits suiting sal.

LOCALITY FACTORS.—Climate and rainfall conditions are given on pages 122 123, 125. Sal requires a fairly mature soil and so is general on the hills wherever the moisture is adequate but is not found on many otherwise suitable alluvial soils. On many soils and slopes it merges imperceptibly into the dry deciduous type. The type extends up to about 1,000 m. in the hills meeting the subtropical forests of pine (group 9) or broadleaved trees (group 8).

C2a. Moist Siwalik sal forest

This subtype occurs on Nahan sandstone with light soil. The sal is of Q. C. III-II. Regeneration is adequate. The following are typical associates :—

I. *Anogeissus latifolia*, *Terminalia tomentosa*.

IIa. *Dendrocalamus strictus*.

III. *Collebrookia oppositifolia*.

IVb. *Thysanolaena*.

ILLUSTRATON.—CHAMPION (1933); Plate 2.

FLORISTICS.—

(i) *Siwalik Hills, Haldwani Division, U. P.* —

I. *Shorea robusta** (a), *Anogeissus latifolia** (a), *Terminalia tomentosa**(f), *Adina cordifolia* (lf), *Pinus roxburghii* (o), (on northern slope or higher ridges) *Lannea coromandelica* (o), *Garuga pinnata* (o), *Terminalia bellerica* (o), *Diospyros tomentosa* (o).

II. *Ougeinia oojeinensis* (a), *Buchanania lanzan* (f), *Semecarpus anacardium* (f), *Ehretia laevis* (f), *Bauhinia* spp. (f), *Cassia fistula, Casearia tomentosa, Emblica officinalis, Olea glandulifera* (o), *Engelhardtia colebrookiana* (o), *Machilus odoratissima* (o).

IIa. *Dendrocalamus strictus** (a).

III. *Colebrookia oppositifolia*, Murraya koenigii, Woodfordia fruticosa, Berberis asiatica* (o), *Indigofera pulchella, Clerodendrum viscosum, Pogostemon plectranthoides.*

IVb. *Heteropogon contortus, Chrysopogon fulvus, Thysanolaena maxima.*

V. *Bauhinia vahlii*, Millettia auriculata.*

(ii) *Saharanpur Division, Uttar Pradesh.* 300 m. Preservation Plot No. 17.—

I. *Shorea robusta** (56%) *Lagerstroemia parviflora* (8%) *Garuga pinnata* (4%) *Adina cordifolia* (1·5%), *Terminalia bellerica* (o), *Mitragyna parvifolia* (o), *Hymenodictyon excelsum* (o), *Stereospermum suaveolens, Anogeissus latifolia*, Bridelia retusa.*

II. *Miliusa velutina* (5%), *Ehretia laevis* (5%), *Mallotus philippensis* (5%), *Sterculia villosa* (1·5%), *Holarrhena antidysenterica* (1·5%), *Casearia tomentosa, Wrightia tomentosa, Ougeinia oojeinensis, Litsea glutinosa, Grewia elastica, Zizyphus xylopyrus, Gardenia turgida, Cassia fistula, Angle marmelos, Butea monosperma, Randia dumetorum.*

III. *Adhatoda vasica, Helicteres isora.*

Percentages based on all trees over 10 cm. d.b.h.

C2b. Moist bhabar sal forest

Two sub-types may be distinguished, one occurring on the dun and gentle bhabar slopes which are gravelly in nature or underlain by gravels and boulders fairly close to the surface and the other developed on high alluvial terraces or *damars* (high river bank) with good loamy soils but no pebbles, jutting out in the tarai and plains. The sal is typically of Q.C. II and regeneration is difficult with fire protection but proceeds slowly in burnt grass. The following species are characteristic :—

I. *Terminalia tomentosa, Lagerstroemia parviflora.*

II. *Mallotus philippensis.*

III. *Clerodendrum viscosum.*

IVb. *Narenga porphyrocoma, Imperata cylindrica.*

C2b(i). Bhabar-dun sal forest

The species which are more characteristic of this subtype are :—

I. *Lagerstroemia parviflora, Terminalia tomentosa* (o).

II. *Mallotus philippensis, Ehretia laevis.*

IVb. *Narenga porphyrocoma.*

FLORISTICS.—

(i) *Dehra Dun Division, Uttar Pradesh.*—

I. *Shorea robusta** (va), *Lagerstroemia parviflora** (o), *Adina cordifolia*, *Kydia calycina.*

II. *Mallotus philippensis**, *Litsea glutinosa*, *Ehretia laevis*, *Syzygium cumini*, *Grewia elastica*, *Cordia dichotoma.*

III. *Clerodendrum viscosum*, *Glycosmis pentaphylla.*

V. *Millettia auriculata*, *Bauhinia vahlii.*

(ii) *Kumaon Bhabar, Uttar Pradesh* (OSMASTON).—

I. *Shorea robusta** (va), *Lagerstroemia parviflora**, *Terminalia tomentosa** (o), *T. bellerica*, *Adina cordifolia* (o), *Ficus* sp. (o).

II. *Mallotus philippensis** (a), *Syzygium cumini* (f), *Ougeinia oojeinensis* (o), *Careya arborea* (o).

IIa. *Dendrocalamus strictus* (o).

III. *Holarrhena antidysenterica* (a), *Randia longispina** (f), *Clerodendrum viscosum* (va), *Millettia auriculata** (a), *Moghania semialata* (f), *Desmodium* spp., *Pogostemon plectranthoides.*

IVb. *Imperata cylindrica*, *Themeda gigantea*, *Vetiveria zizanioides.*

V. *Butea parviflora* (f), *Millettia auriculata* (f), *Bauhinia vahlii* (o).

C2b(ii). Damar sal forest

The species which are more characteristic of this subtype are:—

I. *Adina cordifolia.*

II. *Syzygium cumini*, *Schleichera oleosa.*

IVb. *Themeda arundinacea*, *Sclerostachya fusca.*

V. *Tiliacora acuminata.*

ILLUSTRATION.—CHAMPION (1933); Plate 10.

FLORISTICS.—

(i) *North Kheri Division, Uttar Pradesh*—

I. *Shorea robusta** (va), *Terminalia tomentosa** (5-20%), *Adina cordifolia** (o), *Lagerstroemia parviflora**, *Terminalia bellerica*, *Stereospermum suaveolens*, *Kydia calycina.*

II. *Syzygium cumini**, *Mallotus philippensis**, *Schleichera oleosa**, *Ougeinia oojeinensis*, *Miliusa velutina.*

III. *Clerodendrum viscosum*, *Pogostemon plectranthoides*, *Moghania chappar*, *Glycosmis pentaphylla*, *Ardisia solanacea*, *Indigofera*, *Phoenix acaulis* (burnt areas).

IVb. *Imperata cylindrica*, *Themeda arundinacea*, *Sclerostachya fusca.*

V. *Tiliacora acuminata*, *Bauhinia vahlii*, *Millettia auriculata* (*Calamus tenuis* in wet places along streams).

C2c. Moist tarai sal forest

This subtype occurs on grey clayey alluvium with wet subsoil and is perhaps best characterised by the presence of *Calamus*. The sal is of Q. C. III-IV and there is fair coppice regeneration.

I & II. *Syzygium cumini*, *Trewia nudiflora.*

III. *Ardisia solanacea.*

IV. Very little herbaceous vegetation or grass.

V. *Calamus tenuis.*

FLORISTICS.—

Haldwani Division, U. P.—

I. *Shorea robusta** (va), *Adina cordifolia* (o), *Trewia nudiflora** (f), *Syzygium cumini** (vf.)

II. *Syzygium cumini**, *Lagerstroemia parviflora*, *Litsea glutinosa*, *Elaeagnus latifolia*, *Alangium.*

IIa. *Bambusa arundinacea.*

III. *Clausena pentaphylla*, *Ardisia solanacea.*

V. *Calamus tenuis.*

C2d. Moist plains sal forest

This subtype is also conveniently subdivided into two subtypes according as the soil is light or heavy old alluvium. The light alluvium subtype is found in the western part of the range, frequently occurring on lower levels in the bhabar type (C2b) and drier elevated portions of the tarai type (C2c). The top soil is usually underlain by sandy layers of varying depth. The heavy old alluvium type is characteristic of the lower reaches and occurs in the upper plains from Gorakhpur in Uttar Pradesh to Kamrup in Assam, the soil being usually yellow clayey. It is absent in W. Bengal, the appropriate areas having been cleared long ago.

C2d(i). Western light alluvium plains sal

It generally occurs on sandy alluvium with a dry subsoil. The sal is of Q. C. III with adequate young crops. The characteristic species are :

I. *Terminalia tomentosa*, *T. bellerica*, *Lagerstroemia parviflora.*

II. *Mallotus philippensis.*

IVb. *Themeda arundinacea*, *Saccharum* spp.

ILLUSTRATION. –CHAMPION (1933); Plate 12.

FLORISTICS.—

(i) *North Kheri Division, Uttar Pradesh.*—

I. *Shorea robusta** (va), *Terminalia tomentosa** (10-15%), *T. bellerica**, *Lagerstroemia parviflora**, *Adina cordifolia*, *Kydia calycina*, *Stereospermum suaveolens*, *Schleichera oleosa*, *Ficus* spp.

II. *Syzygium cumini*, *Miliusa velutina*, *Semecarpus anacardium*, *Bauhinia malabarica*, *Grewia* spp., *Mallotus philippensis**, *Butea monosperma*, *Holarrhena antidysenterica.*

III. *Helicteres isora*, *Ardisia solanacea*, *Moghania*, *Clerodendrum viscosum*, *Murraya koenigii.*

IVb. *Themeda arundinacea.*

(ii) *South Kheri Division, Uttar Pradesh.*—

I. *Shorea robusta**, *Terminalia tomentosa**, *Lagerstroemia parviflora**, *Diospyros tomentosa*, *Stereospermum suaveolens*, *Madhuca indica* (o).

II. *Buchanania lanzan*, *Bridelia retusa*, *Syzygium cerasoideum*, *Mallotus philippensis**, *Holarrhena antidysenterica*, *Ehretia laevis*, *Casearia tomentosa*, *Bauhinia malabarica*, *Aegle marmelos.*

III. *Carissa spinarum*, *Zizyphus mauratiana*, *Z. oenoplia*, *Helicteres isora.*

IVb. *Themeda arundinacea*, *Saccharum spontaneum*, *Imperata cylindrica*, *Cymbopogon martinii*, *Bothriochloa intermedia*, *Chrysopogon fulvus*, *Heteropogon contortus.*

V. *Butea parviflora*, *Bauhinia vahlii*, *Ichnocarpus frutescens.*

NOTE.—The subtype takes on a special form in the lowlying *chandars* of the sub-Himalayan tract (*Chandar Sal*). The soil is light to heavy alluvium on a dry subsoil. There is heavy grass growth in which sal regeneration may be abundant but is annually or periodically severely cutback by frost, followed by fire. The characteristic associates are:—

I. *Syzygium cerasoideum.*

IVb. *Themeda arundinacea.*

FLORISTICS.—

Pilibhit, Uttar Pradesh. (SETH)—

I. *Syzygium cerasoideum**.

III. *Helicteres isora*, *Clausena pentaphylla.*

IVb. *Themeda arundinacea* (dominant), *Saccharum spontaneum*, *Vetiveria zizanioides.* Also less commonly *Imperata cylindrica*, *Cymbopogon* sp., *Desmostachya bipinnata*, *Chionachne koenigii*, *Bothriochloa intermedia*, *Narenga porphyrocoma.*

C2d (iii). Eastern heavy alluvium plains sal

Sal of Q. C. III-IV with a low undergrowth of shrubs, with little or no grass. It occurs on yellow clayey alluvium and there are usually enough small poles etc. for coppice working. The characteristic associates are :—

I. *Terminalia tomentosa*, *Dillenia pentagyna*, *Lagerstroemia parviflora.*

II. *Croton oblongifolius.*
III. *Moghania chappar.*
IVb. Herbs and grass light.

ILLUSTRATION.—CHAMPION (1933); Plate 14.

FLORISTICS.—

(i) *Gorakhpur Division, Uttar Pradesh.*—
I. *Shorea robusta**, *Terminalia tomentosa**, *Terminalia bellerica* (o), *T. chebula* (o), *Adina cordifolia*, *Lagerstroemia parviflora**, *Dillenia pentagyna**, *Stereospermum suaveolens*, *Madhuca indica*, *Schleichera oleosa*, *Syzygium cumini*, *S. cerasoideum*, *Pterocarpus marsupium*, *Ficus* spp.
II. *Miliusa velutina*, *Miliusa tomentosa*, *Mallotus philippensis.*
III. *Croton oblongifolius**, *Glycosmis pentaphylla*, *Clerodendrum viscosum*, *Ardisia solanacea*, (along *nalas*) *Moghania chappar*, *Desmodium pulchellum.*
IVb. Heavy grass on open patches of very stiff soil.
V. *Tiliacora acuminata*, *Bauhinia vahlii.*

(ii) *Guma, Goalpara West Division, Assam.* (RAJKHOWA) (on red soils overlying bouldery deposits).—
I. *Shorea robusta** (93%), *Terminalia bellerica** (1%), *Dillenia pentagyna** (1%), *Gmelina arborea*, *Amoora wallichii*, *Lagerstroemia parviflora**, *Artocarpus chaplasha*, *Stereospermum personatum*, *Syzygium cumini*, etc.
II. *Litsea monopetala*, *Aphanamixis polystachya*, *Callicarpa arborea*, *Spondias pinnata*, *Bauhinia* spp.
III. *Morinda angustifolia*, *Clerodendrum viscosum*, *Leea indica*, *Phlogacanthus*, *Eupatorium odoratum.*
IVa. *Alpinia allughas.*
IVb. Scarce, *Microstegium ciliatum* (with heavy grazing).

Percentages refer to trees over 30 cm. girth.

C2d(iv). App. Kamrup sal

Type C2d(iv) develops a dense evergreen undergrowth with protection on yellow clayey alluvial soils and *khurkhani* soils. The sal is of Q. C. III-II. Regeneration is good in burnt grassland but is stopped by protection. Characteristic associates here are :—
I. *Dillenia pentagyna*, *Lagerstroemia parviflora*, *Schima wallichii.*
II. *Careya arborea*, *Glochidion* spp.
IVb. *Imperata cylindrica.*

ILLUSTRATION.—CHAMPION (1933); Plates 15 and 16.

FLORISTICS.—

Kamrup Division, Assam. (JACOB).—
I. *Shorea robusta**, *Dillenia pentagyna**, *Lagerstroemia parviflora**, *Schima wallichii.*
II. *Gareya arborea**, *Gmelina arborea*, *Vitex peduncularis.*
III. *Coffea bengalensis* (under dense canopy).

IVa. Ferns, *Alpinia allughas* (under closed canopy).

IVb. *Imperata cylindrica* (in opener areas), *Carex stroementitia.*

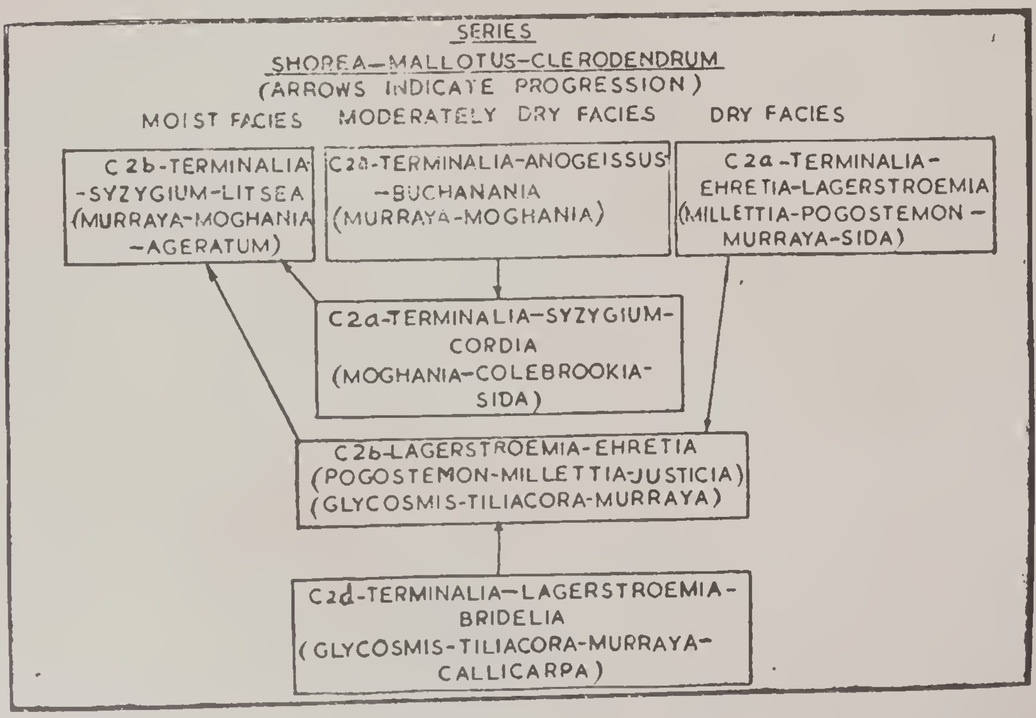
V. Few *Vitis palmata, Butea parviflora.*

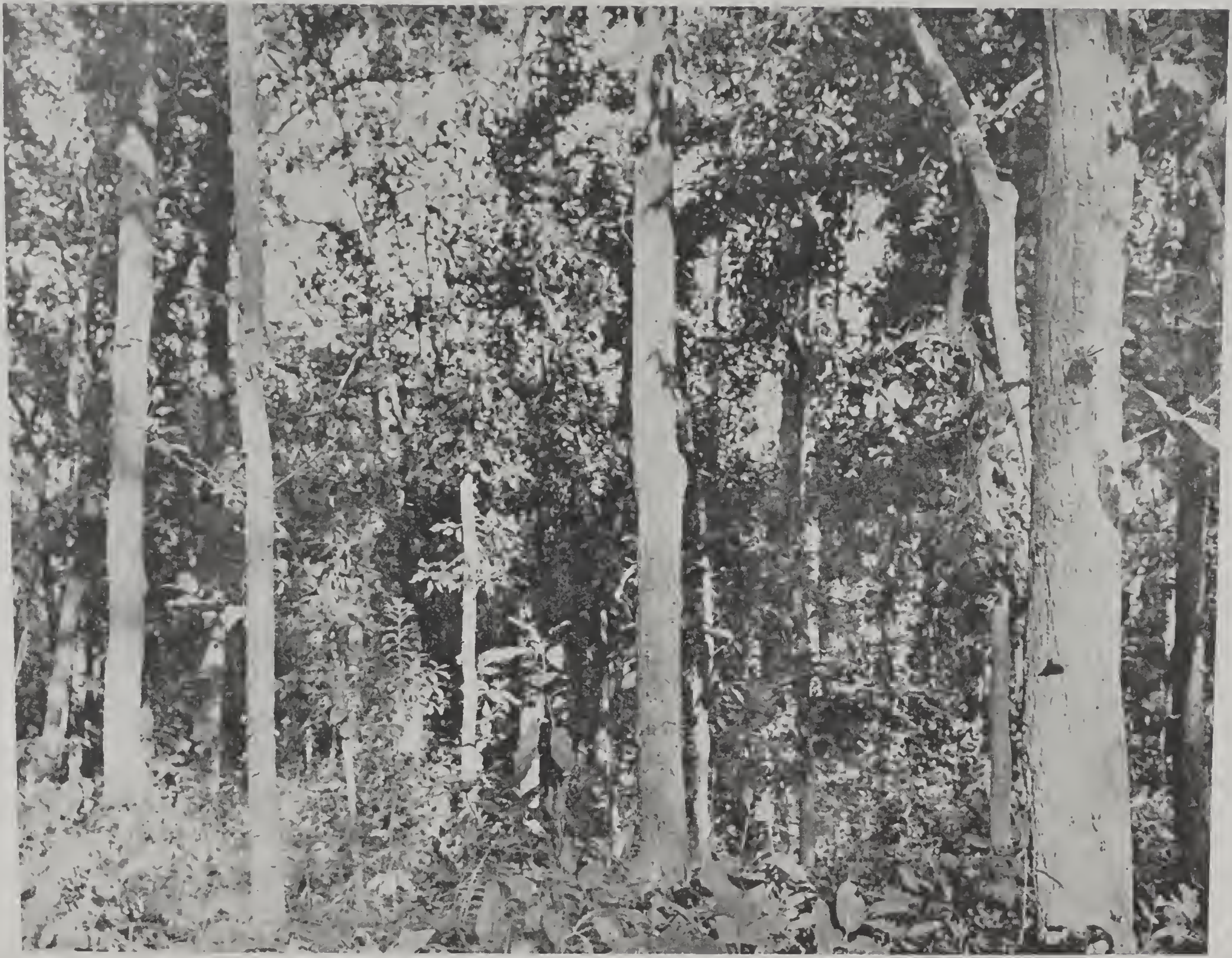
NOTE.—JACOB considers the type to be secondary invasive, sal extending from the foothills down into the alluvial grassland after burning has stopped. In more evergreen patches, occasional old *Artocarpus chaplasha, Cinnamomum cecicodaphne, Garcinia* spp., *Phoebe* spp., and a little bamboo occurs.

GENERAL NOTE ON TYPE 3C/C2.—BHATNAGAR (1960) has distinguished the following communities in the moist sal forests of Uttar Pradesh.

Shorea-Ougeinia-Colebrookia	(Biotic sub-climax community).
Protection ↓	
Shorea-Terminalia-Moghania	(Climax community on elevated portions).
Greater moisture ↓	
Shorea-Syzygium-Randia-Ageratum	(Post-climax in damp valleys etc.).
Greater moisture ↓	
Shorea-Lagerstroemia-Pogostemon	(Climax community on lower plains type areas).

SRIVASTAVA (1962) has recognized six communities in dry, moderately dry and moist facies The societies (undergrown) characteristic of each community are given underneath within brackets.


SERIES
SHOREA—MALLOTUS—CLERODENDRUM
(ARROWS INDICATE PROGRESSION)
MOIST FACIES
MODERATELY DRY FACIES
DRY FACIES
C 2b-TERMINALIA-SYZYGIUM-LITSEA (MURRAYA-MOGHANIA-AGERATUM)
C2a-TERMINALIA-ANOGEISSUS-BUCHANANIA (MURRAYA-MOGHANIA)
C 2a-TERMINALIA-EHRETIA-LAGERSTROEMIA (MILLETTIA-POGOSTEMON-MURRAYA-SIDA)
C2a-TERMINALIA-SYZYGIUM-CORDIA (MOGHANIA-COLEBROOKIA-SIDA)
C 2b-LAGERSTROEMIA-EHRETIA (POGOSTEMON-MILLETTIA-JUSTICIA) (GLYCOSMIS-TILIACORA-MURRAYA)
C2d-TERMINALIA-LAGERSTROEMIA-BRIDELIA (GLYCOSMIS-TILIACORA-MURRAYA-CALLICARPA)



MOIST PENINSULAR SAL FOREST

Original peninsular sal forest of low quality, Baibali, Ghumsur North Division, Orissa.

S. K. Seth

C2e. Moist peninsular sal forest

This type is characterised by significant differences, largely floristic, from its northern counterparts. due to a greater proportion of southern elements. It occurs on crystalline rocks with yellow soils, which are largely *in situ* except in the valleys. As soil and topography vary together, it is helpful to differentiate three subtypes on topography, for hill tops and plateaux, lower hill slopes, and valley bottoms respectively. Frost may be common on higher hill tops as well as in deep valleys. The sal is of Q. C. III-II with adequate natural regeneration. There is light weed growth. The typical associates are :

I. *Pterocarpus marsupium.*

III. *Indigofera pulchella, Phoenix acaulis.*

IVb. *Themeda quadrivalvis.*

C2e(i). Moist peninsular high level sal

The sal extends up over the hills on laterite, trap and crystalline rocks. It is of Q. C. IV. Regeneration is adequate but there is a risk of frost. Typical associates are :

I. *Syzygium cumini.*

IIa. *Dendrocalamus strictus.*

III. *Phoenix acaulis.*

IVb. *Themeda quadrivalvis.*

ILLUSTRATION.—Plate 25.

FLORISTICS.—

(i) *Kalahandi, Orissa* (MOONEY)—

I & II. *Shorea robusta*, Syzygium cumini*, Bauhinia* spp., *Albizzia chinensis, Cedrela toona, Xylia xylocarpa, Emblica officinalis*, Callicarpa arborea, Careya, Dillenia, Elaeodendron.*

III. *Alstonia venenata, Colebrookia, Boehmeria, Grewia.*

IVb. *Arundinella* spp., *Thysanolaena maxima, Themeda triandra.*

(ii) *Supkhar, Madhya Pradesh* (on undulating hills 650—820 m.)—

I. *Shorea robusta*, Terminalia tomentosa, Anogeissus latifolia, Syzygium cumini*, Pterocarpus marsupium*, Madhuca indica, Lagerstroemia parviflora.*

II. *Kydia calycina, Emblica officinalis, Ougeinia oojeinensis, Bridelia retusa, Terminalia chebula, Diospyros tomentosa, Buchanania lanzan, Bauhinia malabarica, Cascaria graveolens, Eriolaena hookeriana, Wendlandia exserta, Zizyphus xylopyrus, Butea monosperma, Randia dumetorum, Aegle marmelos.*

III. *Phoenix acaulis**, *Moghania semialata*, *Desmodium pulchellum*, *Woodfordia floribunda*, *Grewia hirsuta*, *Embelia tsjeriam-cottam*, *Helicteres isora.*

IVb. *Themeda quadrivalvis*, *Imperata cylindrica*, *Heteropogon contortus*, *Eragrostis tenella.*

V. *Bauhinia vahlii*, *Butea superba*, *Smilax macrophylla*, *Zizyphus rugosa.*

ILLUSTRATION.—CHAMPION (1933); Plate 3.

NOTES.—This type occurs on trap, where it is poor. It also occurs on laterite and attains its best development on deep loam. Frost damage is serious at the higher elevations; undergrowth is scanty.

In frosty valleys, usually on black soil, the scattered groups of sal are Q. C. III-IV. The often abundant regeneration in the grass is killed back annually by the frost.

C2e(ii). Moist peninsular low level sal

There is a light shrub growth under the sal, and a moderately dense cover of grass. The subtype occurs on crystalline rocks with yellow loam soils. Sal is Q. C. III. Regeneration is satisfactory. Typical associates are :

I. *Pterocarpus marsupium*, *Terminalia tomentosa.*

II. *Emblica officinalis* (*Mallotus* absent).

IVb. *Themeda quadrivalvis* (No large *Saccharum*).

ILLUSTRATION.—CHAMPION (1933); Plate 6.

FLORISTICS.—

(i) *Angul Division, Orissa.* Preservation Plot No. 3; 350 m.—

I. *Shorea robusta** (va), *Terminalia tomentosa** (va), *Adina cordifolia* (a), *Mitragyna parvifolia* (f), *Lagerstroemia parviflora* (f), *Anogeissus latifolia* (lf), *Bridelia retusa* (lf), *Albizzia procera* (lf), *Hymenodictyon excelsum* (lf), *Pterocarpus marsupium**, *Salmalia malabarica* (o), *Gmelina arborea* (o).

II. *Cleistanthus collinus* (va), *Dalbergia latifolia* (f), *Dalbergia paniculata*, *Syzygium cumini*, *Dillenia pentagyna*, *Careya arborea*, *Diospyros* spp., *Mallotus philippensis.*

IIa. *Dendrocalamus strictus.*

III. *Cipadessa fruticosa**, *Woodfordia fruticosa*, *Clerodendrum viscosum*, *Zizyphus oenoplia.*

V. *Combretum decandrum*, *Butea superba*, *B. parviflora*, *Bauhinia vahlii.*

NOTE.—In the undergrowth evergreen species such as *Canthium dicoccum* and *Cycas circinalis* etc. are also found.

(ii) *S. Raipur Division, Madhya Pradesh*—

I. *Shorea robusta** (va), *Terminalia tomentosa** (f), *Pterocarpus marsupium** (f), *Anogeissus latifolia* (lf), *Madhuca indica* (o).

II. *Emblica officinalis**, *Buchanania lanzan*, *Diospyros melanoxylon*, *Terminalia chebula*, *Kydia calycina*, *Ougeinia oojeinensis*, *Bridelia retusa*, *Bauhinia retusa.*

IIa. *Dendrocalamus strictus* (1).

III. *Indigofera pulchella, Moghania semialata, Phoenix acaulis, Grewia* spp., *Woodfordia fruticosa, Embelia arborea, Ixora tsjeriam-cottam* (1).

IVb. *Themeda quadrivalvis*, Imperata cylindrica, Thysanolaena* (1).

V. *Bauhinia vahlii, Butea superba, Smilax zeylanica.*

C2e(iii). Moist peninsular valley sal

This subtype occurs on downwash from crystalline rocks giving a deep loam soil which carries a moderate shrub growth. Sal is of Q. C. II, and its regeneration is excellent. The characteristic associates are :

I. *Terminalia tomentosa* (no *Dillenia pentagyna*).

III. *Moghania chappar, Indigofera pulchella.*

IVb. *Imperata cylindrica, Themeda triandra.*

ILLUSTRATION.—CHAMPION (1933); Plate 9.

FLORISTICS.—

(i) *Singhbhum damp valley sal.*—

I. *Shorea robusta*, Terminalia tomentosa*, T. bellerica, Adina cordifolia, Pterocarpus marsupium , Schleichera oleosa, Madhuca indica.*

II. *Syzygium cumini*, Schleichera, Ougeinia oojeinensis.*

III. *Clerodendrum viscosum* (a), *Moghania chappar, Indigofera pulchella.*

IVb. *Imperata cylindrica, Themeda triandra.*

V. *Bauhinia vahlii, Millettia auriculata, Butea superba, Dioscorea* spp.

(ii) *Saranda, Bihar.* Preservation Plot No. 1 ; 330 m.—

I. *Shorea robusta*, Terminalia tomentosa*, Adina cordifolia, Mangifera indica, Syzygium cumini*, Alstonia scholaris, Dillenia pentagyna, Diospyros peregrina, Terminalia bellerica, Lagerstroemia parviflora, Anogeissus latifolia, Schleichera oleosa,* etc.

II. *Aphanamixis polystachya, Protium serratum, Mallotus philippensis, Miliusa velutina, Ficus* spp., *Callicarpa arborea, Careya arborea, Glochidion lanceolarium, Canthium dicoccum, Grewia asiatica, Heteropanax fragrans, Vitex peduncularis, Litsea nitida, Bridelia retusa, Ougeinia oojeinensis* and many others.

IIa. *Cephalostachyum pergracile* (o).

III. *Ardisia solanacea, Clerodendrum viscosum, Desmodium* sp., *Moghania* sp.

IVb. *Thysanolaena maxima.*

V. *Bauhinia vahlii, Millettia auriculata, Butea superba, Combretum decandrum, Uvaria hamiltoni, Acacia intsia.*

NOTE.—The evergreen species occur mostly along a stream flowing through the plot.

General Note.— MOONEY (1938) has studied in detail the sal forests of Singhbhum (Bihar) and upper Orissa, and distinguished various floristic associations. He divides the Singhbhum moist sal forests into the following 'types' and notes that the best sal occurs on highly ferruginous soils.

1. High level plateau sal (*Shorea-Bauhinia-Themeda*) on flat topped hills over 800 m. *Bauhinia retusa* most characterstic. [Subtype C2e(i)].
2. Moist hill sal (*Shorea-Wendlandia-Indigofera*) common on good soils except on ultrabasic rocks. [Subtype C2e(ii)].
3. Valley sal (*Shorea-Moghania-Imperata*) on ferruginous loams and loamy clays except on basic rocks. [Subtype C2e(iii)].
4. Damp valley sal (*Shorea-Polyalthia-Croton*) local, *Croton oblongifolius* and *Imperata* typical. [Subtype C2d(ii)].

DS1. Moist sal savannah

NOMENCLATURE.—Included in the *moist sal* of various authors. Sal savannah.

DESCRIPTION.—Open sal forest with heavy grass. The sal occurs in groups with other fire hardy species of the earlier seres such as *Lagerstroemia parviflora*, *Lannea coromandelica*, *Wrightia tomentosa*, *Emblica officinalis*, *Adina cordifolia* and *Salmalia* scattered usually singly. The grasses include *Themeda arundinacea*, *Imperata cylindrica*, *Cymbopogon nardus*, *Erianthus arundinaceus*, *Desmostachya bipinnata* etc.

DISTRIBUTION.— Throughout the Gangetic plains including L. Brahmaputra Valley.

LOCALITY FACTORS.— Those of the moist sal subject to annual heavy grass fires, and frequently to frost.

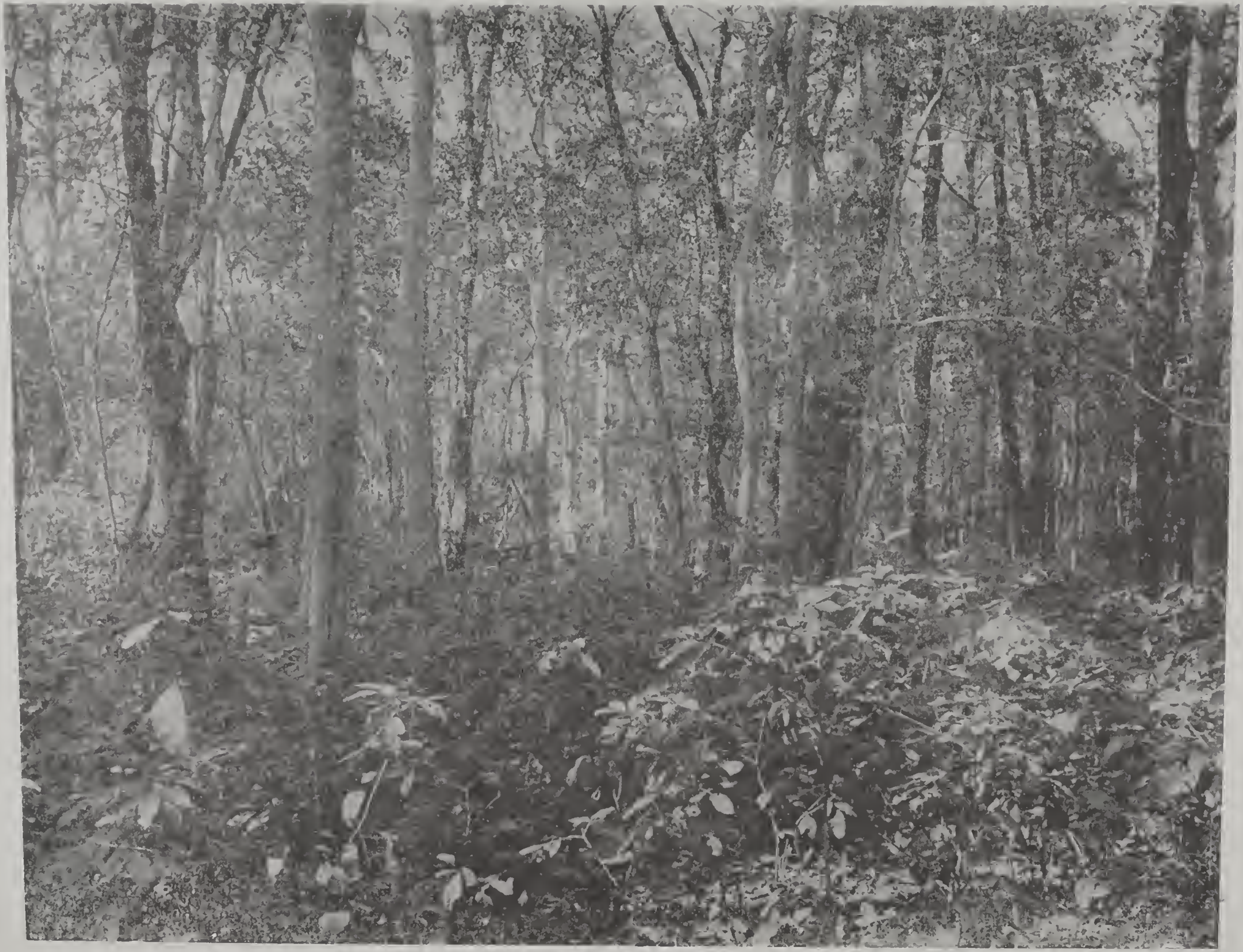
ILLUSTRATIONS.—TROUP; Figs. 21, 26.

FLORISTICS.—

Kamrup, Assam (*High level savannah*). (JACOB)—

I. *Shorea robusta**, *Careya arborea*, *Emblica officinalis**, *Wrightia tomentosa**.
II. *Zizyphus*, *Randia*.
IVa. *Premna herbacea*, *Grewia sapida* (In the rainy season *Leea robusta*, *Curcuma* spp.).
IVb. *Imperata cylindrica* (dominant), *Themeda arundinacea*, *Cymbopogon nardus*, *Apluda*.

General Note.—The type has usually come into existence in old village clearings in sal forest but is difficult to distinguish from tracts where the fire hardy species are slowly invading the mixed deciduous type. When fire protection is introduced in N. Bengal and Assam, the first result is often a dense crop of *Macaranga* which kills out the grass and in turn gives way to high forest.



WEST GANGETIC MOIST MIXED DECIDUOUS FOREST

Cedrela toona, Trewia nudiflora, Salmalia malabarica, Ficus glomerata, Acacia catechu overwood; *Mallotus phillipensis* understorey; semi-evergreen undergrowth of *Glycosmis, Murraya, Clerodendrum* etc.

C3. Moist mixed deciduous forest

C3a. West Gangetic moist mixed deciduous forest

NOMENCLATURE.—Mixed deciduous forest (Working Plans). *Bauhinia* forest (KENOYER).

DESCRIPTION.—Closed forest of medium to good height including a number of dominant species intimately mixed and a good many second storey trees including some evergreens. Climbers are heavy and the undergrowth is usually shrubby with little or no grass, except during the monsoon when a luxuriant herbaceous growth appears.

DISTRIBUTION.— Scattered freely through the hilly tracts occupied by the moist sal type and more locally in the plains.

LOCALITY FACTORS.— In the hills the very varying drainage and moisture retention conditions apparently include many combinations to which sal is not so well adapted as to be able to oust all competitors; details are not available but the sites occupied appear to cover the whole range of moisture conditions under which sal occurs, but are most extensive in the poorer and drier parts.

ILLUSTRATION.—Plate 26.

FLORISTICS.—

(i) *Siwalik hills, Haldwani Division, Uttar Pradesh.*—

I. *Albizzia procera**, *Adina cordifolia**, *Terminalia tomentosa**, *T. bellerica*, *Cedrela toona*, *Garuga pinnata.*

II. *Mallotus philippensis*, *Ougeinia oojeinensis*, *Emblica officinalis.*

IIa. *Dendrocalamus strictus* (b).

III. *Adhatoda vasica*, *Clerodendrum viscosum*, *Colebrookia oppositifolia.*

IV. *Bauhinia vahlii.*

NOTE.—The sites occupied are often terraces where the type is probably seral, but sheltered slopes which remain fairly cool and moist or where there is a subsoil water supply carry a similar type. The ecological status requires study in each case.

KENOYER's *Bauhinia* forest characterised by the prevalence of *Bauhinia retusa*, *B. variegata* and the climbing *B. vahlii* is a local variation met with in various places in the hills.

(ii) *Gorakhpur Division, Uttar Pradesh* (Plains)—

I. *Adina cordifolia**, *Terminalia tomentosa**, *T. bellerica*, *Salmalia malabarica*, *Cedrela toona*, *Lannea coromandelica*, *Trewia nudiflora**, *Mitragyna parvifolia*, *Ficus* spp., *Dalbergia sissoo.*

II. *Lagerstroemia parviflora*, *Syzygium cumini*, *Mallotus philippensis*, *Grewia* spp.

III. *Clerodendrum viscosum* etc.

Note.—In moister places especially on higher riverain alluvium *Trewia, Putranjiva, Aphanamixis polystachya, Bischofia, Alangium salvifolium* also occur (cf. type 4C/FS2, p.167).

(iii) *Singhbhum, Bihar.* (Type IX—*Terminalia-Mallotus-Combretum* : MOONEY).—

I. *Salmalia malabarica*, Adina cordifolia*, Bridelia retusa, Dillenia pentagyna*, Terminalia tomentosa*, Hymenodictyon excelsum*, etc.

II. *Kydia calycina, Mallotus philippensis, Polyalthia cerasoides, Micromelum pubescens, Alangium lamarckii.*

IIa. *Dendrocalamus strictus, Cephalostachyum pergracile.*

III. *Moghania* spp., *Cipadessa fruticosa, Petalidium barlerioides, Colebrookia oppositifolia, Flueggea obovata.*

IVa. *Ruellia beddomei, Daedalacanthus nervosus, Barleria strigosa, Lepidagathis fasciculatus, Pogostemon plectranthoides, Curcuma amada, Zinjiber capilatum, Costus speciosus,* Ferns.

IVb. *Oplismenus compositus, Polytoca barbata.*

V. *Combretum decandrum, Naravelia zeylanica, Uvaria hamiltonii, Atylosia crassa, Mucuna prurita, Mezoneuron cucullatum, Dioscorea* spp.

(iv) *Madhya Pradesh* (General form)—

I. *Terminalia tomentosa*, Pterocarpus marsupium, Lagerstroemia parviflora, Anogeissus latifolia, Salmalia malabarica, Adina cordifolia*, Terminalia chebula, Diospyros tomentosa, Terminalia bellerica, Schleichera oleosa, Soymida febrifuga, Stereospermum personatum, Bauhinia retusa, Madhuca indica, Schrebera swietenioides, Lannea coromandelica, Mitragyna parvifolia, Terminalia arjuna* (along streams), *Shorea robusta* (o).

II. *Ougeinia oojeinensis, Cassia fistula, Kydia calycina, Bauhinia racemosa, Emblica officinalis, Bauhinia variegata, Aegle marmelos, Grewia tiliaefolia, Eriolaena hookeriana, Bridelia retusa, Casearia* spp., *Cleistanthus collinus, Gardenia turgida, G. latifolia, Holarrhena antidysenterica, Garuga pinnata, Morinda exserta, Buchanania lanzan, Wendlandia exserta, Butea monosperma.*

IIa. *Dendrocalamus strictus.*

III. *Helicteres isora, Colebrookia oppositifolia, Petalidium barlerioides, Pogostemon plectranthoides, Moghania, Embelia, Strobilanthes* spp.

V. *Bauhinia vahlii.*

Note.—This type is practically the same whether in association with sal or teak and so links the northern and southern moist deciduous types. To it are to be relegated the better quality miscellaneous forests which appear climax in the sal tract but do not carry sal nor have *Terminalia tomentosa* predominant.

ECOLOGICAL STATUS.—Most of the moderately moist mixed deciduous forest in which sal is scarce or absent appears to be only seral in status and the indications are that once the progression has reached a point at which sal can obtain a footing, it relatively quickly establishes its dominance and characterises the climax formation. The apparently stable occurrences in more mesophytic habitats can usually be associated with special sites and can be considered as edaphic variations on the climax or as post-climax communities.

In these mixed forests areas can be found in some part of the range where an individual species, for whatever reason,occurs as more or less the sole dominant,*e.g.*, *Xylia*, *Pterocarpus marsupium*, etc.

C3b. East Himalayan moist mixed deciduous forest

This type is constituted to include the deciduous forests occupying well drained soils on the *bhabar* terraces and plateaux of the outer Himalayan ranges upto 500—650 m. in the heavy rainfall zone of the E. Himalayas.

NOMENCLATURE.—Dry mixed forest (Working Plans).

DESCRIPTION.—A tall more or less closed forest in which the individual trees often run to large size. Species usually well mixed by small groups. There is abundant underwood and shrubby undergrowth without grass unless burnt. With burning, grass may become heavy though coarse tufted species are absent.

DISTRIBUTION.—Foot of the Himalaya in Bengal and Assam.

LOCALITY FACTORS.—A high rainfall over 2,500 mm. and often nearer 5,000 mm., short dry season but a porous very effectively drained soil. No frost.

FLORISTICS.—

(i) *U. Bhabar tract, N. Bengal* (Dry mixed forest of Working Plans)—

I. *Lagerstroemia parviflora** (va), *Terminalia bellerica** (f), *Sterculia villosa* (a), *Salmalia malabarica* (f), *Schima wallichii* (f).

II. *Careya arborea*, *Bauhinia purpurea*, *Amoora* spp.

NOTE.—Once again, it is by no means certain that this is not a seral type, succession being slow on the intensively drained soils occupied.

(ii) *Linear Sample Plots No. 2 and 5, Buxa Division*—

I. *Terminalia bellerica** (5·6%), *Aphanamixis polystachya** (8·5%), *Sterculia villosa* (3·2%), *Stereospermum personatum* (3·1%), *Cedrela toona* (3·1%), *Shorea robusta* (2·4%), *Lagerstroemia parviflora** (2·1%), *Dillenia pentagyna* (1·0%), *Gmelina arborea* (1·0 %), *Dysoxylum binectariferum* (1·0%).

II. *Litsea monopetala* (14·0%), *Premna integrifolia* (11·5%), *Mallotus philippensis* (8·6%), *Wrightia tomentosa* (5·2%), *Machilus* sp. (4·7%), *Callicarpa arborea* (4·0%), *Careya arborea* (2·1%), *Oroxylum indicum* (1·9%), *Eurya* sp. (1·9%) (Plot Records).

NOTE.—This constitution suggests that part of the line at least runs through secondary forest but this probability has not been followed up.

(iii) *Plateau forests, Buxa Division* (*"Plateau type" of Working Plans*)—

I. *Schima wallichii** (va), *Cedrela toona, Duabanga sonneratioides, Tetrameles nudiflora, Lagerstroemia parviflora, Sterculia villosa.*

NOTE.—This form is related to the Upper Bhabar (or Bamba) sal; it includes very few evergreens, a feature probably connected with past burning.

(iv) *Linear Sample Plot No. 7, Khairbari, W. Bengal*—

I. *Dillenia pentagyna, Sterculia villosa, Lagerstroemia parviflora, Bischofia, Careya, Salmalia.*

II. *Litsea monopetala, Syzygium cumini, Meliosma simplicifolia, Premna, Mallotus, Wrightia, Callicarpa arborea, Crataeva unilocularis.*

III. *Laportea crenulata*, etc.

2S1. Northern secondary moist mixed deciduous forest

DISTRIBUTION.—In the regions of higher rainfall corresponding to semi-evergreen and occasionally evergreen forest in Bengal, Assam and Orissa, less frequently or recognisably in the moist deciduous tract itself.

DESCRIPTION.—Generally similar to the climax type but recognisable by the absence of old trees apart from occasional specimens left for shade, fruit or other purposes (figs, mango, etc.). Other species characteristic of secondary growth may persist though they are mostly short lived and soon lost.

LOCALITY FACTORS.—Climate mostly that of the semi-evergreen type. The original forest has been destroyed, usually by clear-felling for shifting or more or less permanent cultivation, which has later been more or less completely abandoned and reverted to forest under varying conditions.

FLORISTICS.—

(i) *Dhuanali, etc., Puri Division, Orissa* (moist mixed forests of the Working Plans)—

I. *Mangifera indica** (E), *Anthocephalus cadamba, Alstonia scholaris* (E), *Dillenia pentagyna, Schleichera oleosa, Terminalia tomentosa, Protium serratum, Melia composita, Bridelia retusa.*

II. *Miliusa velutina, Glochidion lanceolarium, Careya arborea, Zizyphus glaberrima, Polyalthia cerasoides, Strychonos potatorum, Mallotus philippensis,*

IIa. *Bambusa arundinacea.*

SECONDARY EUPHORBIACEOUS SCRUB

Dense crop of *Macaranga denticulata* succeeding treeless heavy savannah grass.
Jalpaiguri Division, West Bengal.

R. S. Troup

III. *Glycosmis pentaphylla, Psychotria adenophylla, Phyllochlamys spinosa, Maba buxifolia, Strobilanthes scaber.*

IV. *Combretum decandrum, Bauhinia vahlii.*

NOTE.—The general evenaged appearance and the prevalence of big low branched mangoes indicate a former clearing beyond doubt. With fire protection, an evergreen undergrowth is rapidly developing. This forest is being successfully brought under teak plantations.

GENERAL NOTE.—For practical purposes, secondary moist deciduous forest replacing primary forest of the same type need not be differentiated. As noted, almost all the primary forest has been fundamentally influenced by human activities and only in the case of complete destruction is a marked difference likely to result. Tree growth is liable to be extremely slow in getting re-established.

MOONEY (1938) states that in Singhbhum recolonisation starts very slowly *Woodfordia fruticosa, Wendlandia tinctoria, Gardenia gummifera* and *Phoenix acaulis* are the first to colonise. After protection, *Imperata* usually comes in followed by *Moghania chappar, Randia dumetorum* etc. and finally sal.

2S2. (Secondary Euphorbiaceous scrub)

ILLUSTRATION.—Plate 27.

This type is described on page 146 (General Note).

GENERAL EDAPHIC AND SERAL TYPES OF MOIST DECIDUOUS FORESTS

3/E1. Terminalia tomentosa forest

NOMENCLATURE.—The name is taken from the marked predominance of *Terminalia tomentosa,* but this species occurs and may even predominate locally under a wide range of conditions in most forms of deciduous forest.

DESCRIPTION.—Typically closed forest of good height and development with a lower storey tree canopy of smaller trees and a shrubby undergrowth which (if not burn) has little grass except in water logged openings.

DISTRIBUTION.—Throughout the sal region on heavy or wet soils and so usually in valleys and hollows and on clayey alluvial patches.

LOCALITY FACTORS.—The heavy soil is characteristic. In this moist deciduous type, the soil is moisture retentive and good growth is usual, in contrast with adjoining dry deciduous types in which also *Terminalia tomentosa* may predominate. (Cf. p. 201.) From the sites occupied, frost is fairly frequent.

ILLUSTRATIONS.—TROUP; Figs. 197-200.

FLORISTICS.—

(i) *Gorakhpur, U. P.*—

I. *Terminalia tomentosa*, Shorea robusta* (o), *Salmalia malabarica.*

II. *Syzygium cumini, Mallotus philippensis.*

III. *Clerodendrum viscosum.*

(ii) *Singhbhum, Bihar*—

I. *Terminalia tomentosa**, *T. bellerica*, *T. arjuna* (by water side only), *Shorea robusta* (singly of large size), *Salmalia malabarica*, *Sterculia villosa*.

II. *Mallotus philippensis*.

III. *Clerodendrum viscosum*, *Moghania* spp., *Ardisia solanacea*.

(iii) *Sitanadi, S. Raipur Division, M. P.*—

I. *Terminalia tomentosa**, *T. bellerica*, *T. arjuna* (by water side only), *Mitragyna parvifolia*, *Adina cordifolia*, *Pterocarpus marsupium*, *Schleichera oleosa*. *Syzygium cumini*, *Garuga pinnata*, *Grewia tiliaefolia*, *Dalbergia paniculata*.

II. *Ougeinia oojeinensis*, *Syzygium cumini*, *Cleistanthus collinus*.

III. Shrub growth.

IVb. No grass.

V. *Bauhinia vahlii*, *Butea superba*.

NOTE.—This type should be seral but from the sites occupied in narrow valleys, among the hills, forms at least a very stable sub-climax. Compare however, TROUP, p. 515.

3/1S1. Low alluvial savannah woodland (Salmalia-Albizzia)

NOMENCLATURE.—High savannah, *Salmalia-Albizzia* type (RAJKHOWA).
Bombax-Albizzia-Lagerstroemia hylis (BOR).
Riverain deciduous forest (WORKING PLANS).

DESCRIPTION.—This is the most extensively occurring tall grass savannah forest type of India. Scattered trees of the early seres of the normal succession on new riverain soils, almost entirely restricted to fire hardy species, often of quite good height growth (poorer on the heavier soils) standing over very dense tall grass growth in which *Themeda*, *Erianthus* and *Saccharum* are characteristic genera. There are also patches of fire hardy shrubs such as *Zizyphus mauratiana*.

DISTRIBUTION.—Throughout the Gangetic plains including the Brahmaputra valley.

LOCALITY FACTORS.—The type is met with on the more stable riverain flats which tend to be flooded during the rainy season but which dry out during the rest of the year, the subsoil water level sinking to 2-4 m. or sometimes much more. The soil is alluvial, mainly sandy but with local clay patches particularly in depressions marking old channels which have become blocked and silted up; such depressions often carry a different type. There is usually a thin surface layer of loam soil with more or less humus. Frost is not uncommon particularly in lowlying areas. Fires usually sweep through annually, and under forest management are generally set early in the year as a protection measure for the adjoining more valuable forests, and to minimise damage done to trees standing in the grass.

ILLUSTRATION.—SMYTHIES 1921; Pl. VI.

FLORISTICS.—

(i) *North Kheri Division, Uttar Pradesh*—

I. *Salmalia malabarica**, *Adina cordifolia**, *Butea monosperma*, *Dalbergia sissoo*, (*Ficus glomerata*, *Trewia nudiflora*, *Acacia catechu*).

II. *Syzygium cerasoideum*, *Randia uliginosa*, (*Schleichera oleosa*, *Syzygium cumini*).

NOTE.—The species in brackets are met with in low alluvium. On the edges of wet depressions *Syzygium cumini*, *Trewia nudiflora*, *Putranjiva roxburghii*, *Ficus glomerata*, *Terminalia arjuna*, *Celtis* also occur.

(ii) *Bengal Duars*—

I. *Salmalia malabarica**, *Albizzia procera**, *Dillenia pentagyna*, *Terminalia bellerica*, *Gmelina arborea*.

II. *Syzygium cerasoideum*, *Careya arborea*, *Sterculia villosa*, *Callicarpa arborea*.

III. *Zizyphus mauratiana*.

IIIa. *Saccharum procerum*, *Erianthus* sp., *Themeda gigantea*, *Saccharum spontaneum*, *C. nardus*, *Arundinella intricata*, *Phragmites maxima* (wet ground).

NOTES.—The succession with fire protection has frequently been described. *Macaranga denticulata* (cf. Plate 27, p. 151). *Trema orientalis* and *Callicarpa arborea* are early arrivals, whilst *Scitamineous* herbs such as *Alpinia allughas* spread rapidly in damp places. The deciduous trees prevented from growing up by the fires become established and if *Shorea* exists in the vicinity its spread is more rapid in the eastern part of the range than in the western.

(iii) *Jaldapara Sanctuary, Cooch Behar Division, Bengal*—

I/II. *Salmalia** (o), *Albizzia procera** (o), *Bischofia* (f), *Acacia catechu* (la), *Dillenia indica* (f), *Trewia* (lf).

IVb. Grasses very dense, 4-5 m. high, *Saccharum procerum**(a), *S. spontaneum*, *Erianthus arundinaceus*, *Phragmites** (a), *Arundo*, *Themeda gigantea* (f), *Narenga porphyrocoma*, *Imperata* (la), *Themeda arundinacea* (la), *T. villosa* and many smaller species.

(iv) *Nambar Reserve, Assam* (RAJKHOWA)—

I/II. *Salmalia** (2%), *Albizzia procera* *(9%), *A. lucida* (3½%), *Bischofia* (5½%), *Cordia dichotoma* (8%), *Dillenia indica* (5%), *D. pentagyna* (3%), *Garuga pinnata* (3%), *Premna bengalensis*(4%), *Sterculia villosa* (3½%), *Trewia nudiflora* (4%).
Percentages of trees over 3 ft. girth.

3/1S2. Eastern hollock forest (Terminalia myriocarpa)

1S2(a). Terminalia—Lagerstroemia

NOMENCLATURE.—

Assam.—Lagerstroemia-Terminalia association (ROWBOTHAM).

Duabanga-Pterospermum-Terminalia association (in part). (ROWNTREE).

High level riverain (*Terminalia myriocarpa*) (RAJKHOWA).

DISTRIBUTION.—On the young alluvium of the larger rivers especially in Upper Assam.

DESCRIPTION.—An irregular forest in which *T. myriocarpa* and/or *Lagerstroemia speciosa* usually predominate being more or less deciduous, with a predominantly evergreen underwood. Often there is heavy grass.

LOCALITY FACTORS.—Most of the area occupied receives a rainfall of 1,500 mm. or more, but the type is probably mainly dependent on sub-soil water. The soil is typically light; it may be silty but is rarely clayey. It is liable to erosion, flooding and silt deposition but is well drained.

ILLUSTRATION.—Plate 28.

FLORISTICS.—

I/II. *Terminalia myriocarpa** (42%), *Pterospermum acerifolium** (7½%), *Duabanga* (4%), *Vatica lanceaefolia* (4½%), *Vitex peduncularis* (3½%), *Elaeocarpus rugosus* (3%), *Ailanthus grandis* (3%), *Crataeva* spp. (1%), (RAJKHOWA).

ECOLOGICAL NOTE.—When present, the grass renders the forest liable to fire damage, checking further development. With protection, it proceeds through the next type towards the local climax. The succession may however be thrown back by erosion or deep silt deposition.

1S2(b). Terminalia—Duabanga

NOMENCLATURE.—

Assam.—Duabanga-Pterospermum-Terminalia (ROWNTREE).

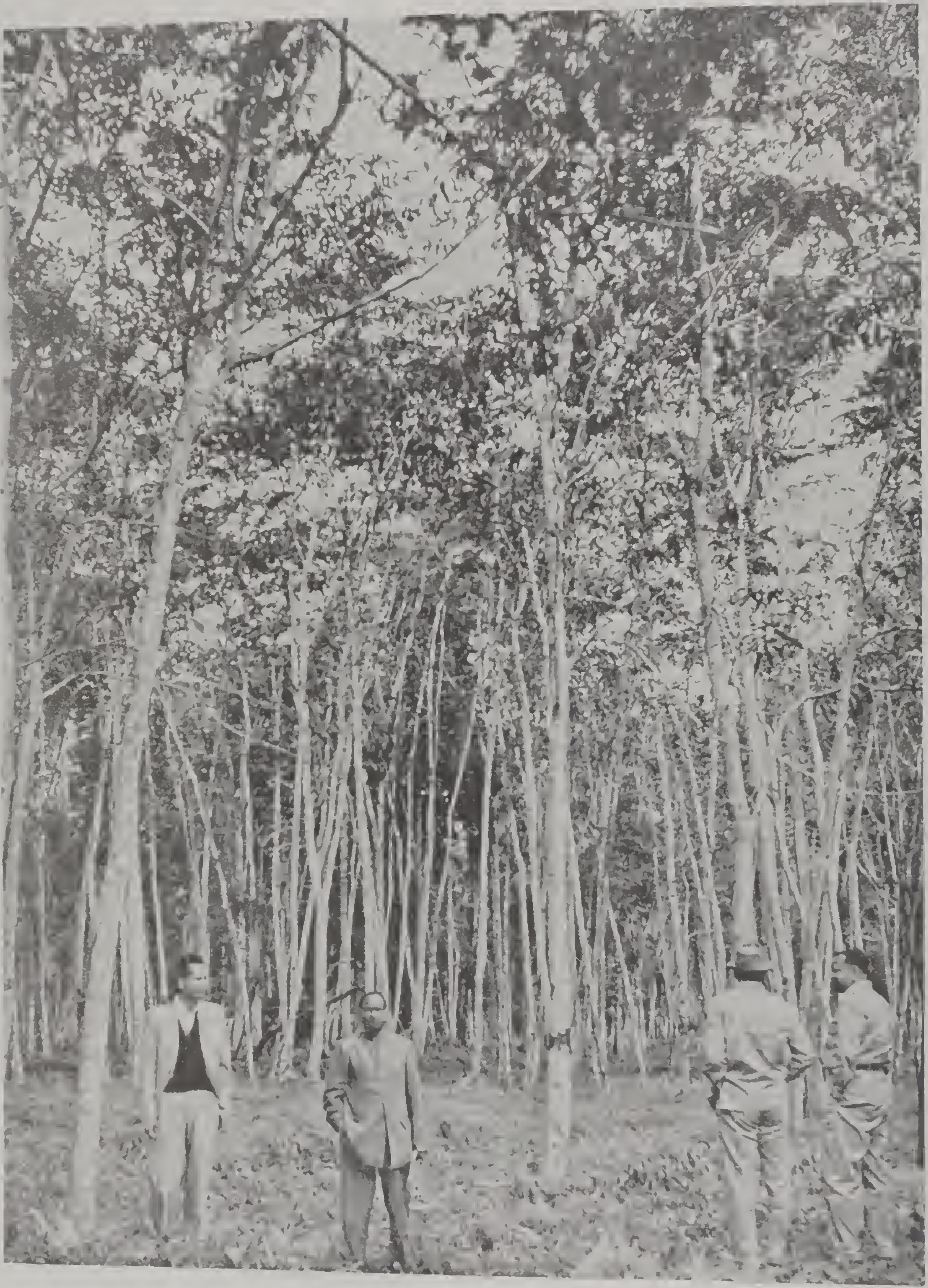
High level riverain (*Terminalia myriocarpa*) in part. (RAJKHOWA).

DESCRIPTION.—This type is a later stage of the preceding in which the evergreen trees have successfully invaded, contributing to the dominant canopy and forming a fairly complete second storey.

DISTRIBUTION.—In the sub-Himalayan tracts of Assam and Bengal extending south of the Brahmaputra to the foot-hills of the Naga and Patkoi hills.

LOCALITY FACTORS.—As for 1S2(a).

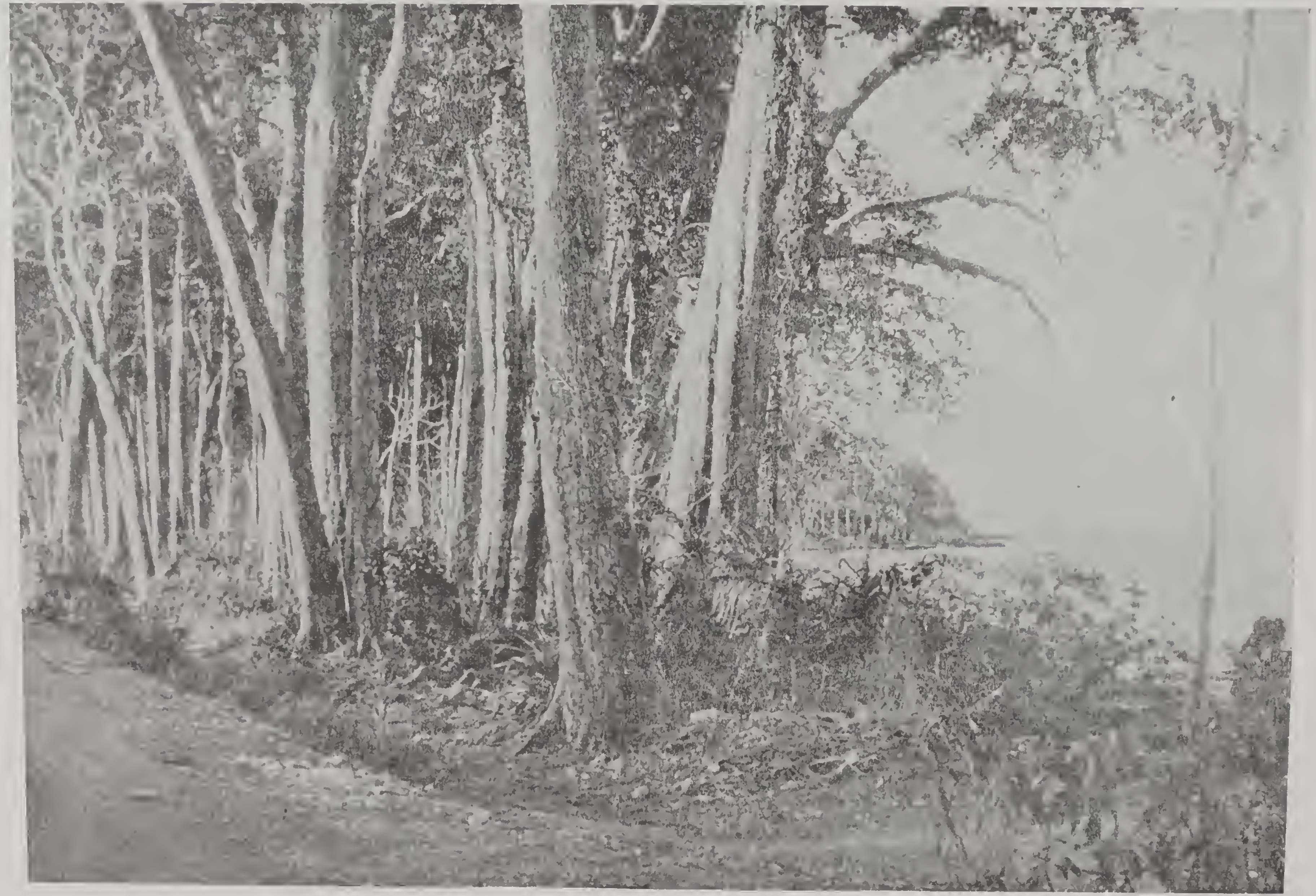
ILLUSTRATIONS.—BOR (1938): Plates 15 and 16.



EASTERN HOLLOCK FOREST

Hollock has colonised an area devastated by floods. Crop five years old. Namphuk, Tirap Division, N. E. F. A.

S. K. Seth



LITTORAL FOREST

Manilkara littoralis and *Calophyllum inophyllum*; Sample Plot, Kauriaghat, South Andamans.

H. G. Champion

FLORISTICS.—

(i) *Pasighat, Sadiya Division, Assam* (PURKAYASTHA)—

*Terminalia myriocarpa** (42%), *Pterospermum* (7½%), *Duabanga** (4%), *Vatica lanceaefolia* (4%), *Vitex peduncularis* (3%), *Elaeocarpus rugosus* (3%), *Ailanthus grandis* (3%).

Percentages refer to trees over 3′ g.b.h.

(ii) *Bhoreli Reserve, Assam* (BOR).—

I. *Terminalia myriocarpa**, *Pterospermum*, *Duabanga**, *Pterygota alata*, *Salmalia*, *Chukrassia*, *Garuga*, *Morus laevigata*.

II. *Albizzia lucida*, *Dillenia indica*, *Litsea khasyana*, *Syzygim oblatum*, *Turpinia*, *Talauma*, etc.

III. *Allophylus cobbe*, *Strobilanthes coloratus*.

V. *Calamus tenuis*, *Entada*, *Schefflera*, *Ficus* spp.

2S1. (Dry bamboo brakes)

This is described under 5/E9, page 220.

GROUP 4. LITTORAL AND SWAMP FORESTS

Sub-group 4A. Littoral Forests

L1. Littoral forest

NOMENCLATURE.—The terms beach and dune forest are in general use.

DESCRIPTION.—The most characteristic species is the tall evergreen but very light foliaged *Casuarina* which often forms an almost pure fringe on sandy beaches and dunes along the sea face; in the Andamans *Manilkara littoralis* takes its place. Scattered smaller evergreen trees occur with fewer deciduous trees and these in the absence of *Casuarina* form the dominant canopy. There are numerous shrubs, and where the undergrowth is light, maritime grasses (*Spinifex*, etc.) and surface creepers are conspicuous, binding the sand. In the depressions (which are swampy usually with saline water), the tidal species are poorly developed with a dense under-growth; if the water is fresher tall grasses (*Phragmites*) occur.

DISTRIBUTION.—All round the coast wherever a fair width of sandy beach occurs including sandy bars on the sea face of the river deltas.

LOCALITY FACTORS.—The habitat is an exposed one with pronounced characteristics. The soil is sea sand often blown and accumulating in low dunes, with adequate lime from shell fragments but poor in nitrogen and mineral nutrients. It is very coarse, porous, and dry at the surface, but the water table is usually only a few feet down; the water is fresher than might at first be expected, but often brackish. Strong winds, often salt laden, act as dessicating agents with strong insolation and radiation from the bare sand rendering conditions pronouncedly xerophytic. The temperature is moderated by the proximity of the sea and by sea breezes. Rainfall varies with locality from 760 mm. to over 5000 mm; its influence is mainly seen in the rate at which the formation progresses towards the climate climax. The Indian coast line all lies within the tropics.

Temperature.—No data are available from within the littoral forest but the four stations selected are in the near vicinity and except Madras are only a few metres above sea level.

Temperature (centigrade)

Littoral Forests

Month	Orissa PURI 6 m.			Madras MADRAS 20 m.			Madras TUTICORIN 4 m.			Mysore KARWAR 4 m.		
	Mean	Mean max.	Mean min.	Mean	Mean max.	Mean min.	Mean	Mean max.	Mean min.	Mean	Mean max.	Mean min.
January	22·2	26·7	17·6	24·6	29·6	19·5	25·1	27·7	22·3	25·8	31·8	19·7
February	24·4	28·3	20·6	25·8	31·3	20·2	25·7	28·2	23·1	25·5	30·6	20·3
March	27·9	30·2	25·6	27·7	33·0	22·4	27·1	29·6	24·7	26·7	30·9	22·4
April	28·6	30·9	26·2	30·4	35·3	25·6	31·4	37·1	25·7	27·8	31·3	24·4
May	29·6	32·0	27·3	33·1	38·5	27·6	30·5	34·5	26·4	28·7	31·4	25·9
June	29·4	31·7	27·2	32·4	37·6	27·3	31·0	35·4	26·6	26·2	28·3	24·0
July	28·7	30·7	26·7	31·0	35·7	26·3	30·3	34·1	26·6	25·8	27·7	24·0
August	28·7	30·9	26·4	30·4	34·9	25·8	30·3	34·2	26·4	25·6	27·4	23·8
September	29·0	31·4	26·5	29·8	34·4	25·1	29·3	32·9	25·8	26·4	28·9	23·9
October	27·9	30·8	25·0	28·1	32·3	23·9	29·1	32·8	25·3	26·7	29·6	23·8
November	24·9	29·2	20·7	25·9	29·7	22·2	26·7	29·7	23·6	25·4	31·1	19·7
December	21·9	26·9	16·9	24·7	28·9	20·5	24·4	27·4	21·5	25·2	31·3	19·1
M. A. T.	26·9	..	..	28·7	..	..	28·4	..	..	26·3	..	..
Annual mean maximum	30·4	..	..	33·4	..	..	31·9	..	..	30·0	..	..
Highest record	39·4	..	..	45·0	..	..	?	..	..	?	..	..
Annual mean minimum	23·9	..	..	23·9	..	..	24·8	..	..	22·6	..	..
Lowest record	10·6	..	..	13·9	..	..	?	..	..	?	..	..
No. of years	50	..	..	60	..	..	upto 1955	..	..	upto 1955	..	..

Rainfall.—As precipitation is in no way a limiting factor for this type, a wide range of rainfall is found as shown in the appended table.

Rainfall (millimetres)

Littoral Forests

Month	Orissa PURI 6 m.	Madras MADRAS 20 m.	Madras TUTICORIN 4 m.	Mysore KARWAR 4 m.	Gujarat PORBUNDAR 5 m.
January	12	36	26	1	3
February	27	10	25	1	3
March	17	7	29	0	2
April	18	16	43	12	..
May	71	26	21	86	5
June	208	47	5	951	113
July	300	91	4	944	210
August	301	116	6	542	95
September	248	119	16	276	31
October	169	306	141	147	7
November	63	355	183	42	8
December	5	138	85	6	3
Total for year (M.A.R.)	1,438	1,268	582	3,006	479
No. of rainy days	67	57	29	104	24
No. of months with less than 50 mm.	5	6	9	6	9
M. A. Humidity	78	72	69	80	?
No. of years	50	60	71	57	?

ILLUSTRATION.—Plate 29.

FLORISTICS.—(CHENGAPPA).

(i) *Andamans*—

I. *Manilkara littoralis.**

II. *Pongamia pinnata*, *Morinda citrifolia*, *Erythrina variegata* var. *orientalis*, *Calophyllum inophyllum*, *Terminalia catappa*, *Barringtonia asiatica*, *Cordia subcordata*.

IIIa. *Thespesia populnea, Hibiscus tiliaceus, Pandanus tectorius.*

IVa. *Ipomoea pes-caprae, Crinum asiaticum, Vigna retusa, Scaevola frutescens.*

V. *Mucuna gigantea, Colubrina asiatica, Caesalpinia bonduc.*

NOTE.—Lining the top of the beach are *Scaevola frutescens* or a fringe of *Hibiscus tiliaceus* with *Colubrina asiatica, Smythea calpicarpa, Crinum asiaticum, Caesalpinia bonduc, Desmodium umbellatum, Mucuna gigantea, Clerodendrum inerme* and less frequently *Dalbergia tamarindifolia* ; again there may be only *Pandanus tectorius* thickets. Above the beaches, the twining *Ipomoea pes-caprae* , *Vigna retusa, Clitoria ternata* may occur. On the west coast, *Tournefortia argentea, Pemphis acidula, Sophora tomentosa* are also seen.

Behind the shrubs, in addition to species noted in the description, *Guettarda speciosa, Ixora brunnescens, Cycas rumphii, Hernandia peltata, Heritiera littoralis* and *Gyrocarpus jacquinii* may also occur (after PARKINSON).

(ii) *Great Nicobar Islands.* (SAHNI)—

I. *Casuarina equisetifolia*, Calophyllum inophyllum, Terminalia catappa.*

II. *Barringtonia asiatica, Erythrina variegata, Guettarda speciosa, Pongamia pinnata, Heritiera littoralis, Cerbera manghas, Ochrosia oppositifolia.*

III. *Ixora* spp., *Cycas rumphii.*

Epi. *Asplenium nidus, Dendrobium* spp., *Bulbophyllum* spp.

(iii) *Sunderbans, Bengal*—

I/II. *Hibiscus tiliaceus*, Thespesia populnea*, Erythrina variegata, Ixora arborea, Vitex negundo, V. trifolia, Trewia nudiflora, Dolichandrone spathacea, Tamarix troupii.*

III. *Acanthus ilicifolius*, Crotalaria* spp., *Lippia geminata, Oryza coarctata, Saccharum spontaneum.*

GENERAL NOTE.—Apart from the deltas, the type is very stable, only the flora described being able to persist in the loose blown sand, but where accretion is taking place the sand may get fixed, acquiring some humus and becoming more loamy, and hardy colonists of the adjoining floras come in. *Borassus* and *Phoenix* are often to be seen behind the recently fixed dunes in the drier regions whilst coconut is planted in the moister climates.

Sub-group 4B. Tidal Swamp Forests

GENERAL DESCRIPTION.—Tidal forests vary so much in such short distances that a general description is difficult. The finest forest is found on ground which is flooded at every high tide with only moderately brackish water, and is an evergreen closed high forest 30 m. or more in height of *Heritiera* or less commonly *Bruguiera*. There may be an underwood of younger trees of the same species or of others such as *Ceriops*, two storeyed forest being of common occurrence owing to the prevalence of trees whose maximum height is only 5-10 m. mixed with others capable of further development. The soil in these forests is typically bare mud, particularly in the best *Heritiera*, though masses of regeneration may cover it locally. At higher levels flooded only at spring tides, there is more and more varied undergrowth of *Pandanus*, canes, ferns, etc. and if very brakish much *Phoenix paludosa*. Nearer the sea with definitely salt water, the *Heritiera* is replaced by the *Rhizophoraceae* and other smaller trees which colonise the mud banks and flats. Species are here relatively few and mostly occur gregariously; practically all are evergreen with simple coriaceous leaves. Grasses are rare (*Oryza*). Climbers are usually few though *Derris* is locally abundant. Epiphytes are fairly numerous (notably the tuberous *Hydnophytum*). Some species, particularly among the *Rhizophoraceae*, grow on stilt roots and others send up knees (*Heritiera*) or pointed pneumatophores (*Sonneratia*, *Carapa*, *Amoora*), whilst *Litsea* sp. has long bifurcating aerial roots. Vivipary is characteristic of the *Rhizophora* spp., and nearly all seeds or fruits are large but lighter than water, even in families (*Meliaceae*) in which winged seeds are usual. (*Sonneratia* is exceptional with minute seeds). BLATTER (1905) has given some biological notes on the Bombay mangroves. CURTIS's Working Plan (1931-51) gives a good account of the Sunderbans forests.

DISTRIBUTION.—Of the large and important area carrying tidal forests in the delta of the Ganges and Brahmaputra rivers, only the poorer part west of the Raimangal branch now falls within India. CURTIS's working plan gives a detailed stockmap for each compartment showing the distribution of the chief species with density and height.

There is a considerable area under mangroves in the mouths of the creeks and short rivers. There are also remnants at the estuaries of the Mahanadi, Krishna and Godavari rivers on the East Coast, but very little in the creeks on the West Coast.

LOCALITY FACTORS.—

Temperature.—Mean annual temperature is very close to 27°C equally on the Ganges and Godavari estuaries as on the Andamans and West Coast creeks. The range is small, mean maximum being approximately 30° C at all stations and the mean minimum 22° C to 24° C. Data are given for Khulna, Kakinada (Godavari mouth), Port Blair in the Andamans and Calicut on the West Coast.

Temperature (centigrade)

Tidal Swamp Forests

Month	Andaman Islands PORT BLAIR 80 m.			West Bengal CALCUTTA 6 m.			Andhra Pradesh KAKINADA 8 m.			Kerala CALICUT 8 m.			Maharashtra BOMBAY 11 m.		
	Mean	Mean max.	Mean min.	Mean	Mean max.	Mean min.	Mean	Mean max.	Mean min.	Mean	Mean max.	Mean min.	Mean	Mean max.	Mean min.
January	25·5	29·0	22·0	29·5	26·4	12·6	23·2	27·3	29·1	26·3	31·1	21·6	23·9	28·4	19·3
February	25·6	29·7	21·4	22·0	28·7	15·2	25·4	29·8	20·9	27·1	31·4	22·8	24·1	28·4	19·7
March	26·4	30·8	21·9	27·1	33·6	20·4	28·2	33·2	23·1	28·4	32·3	24·5	26·2	30·1	22·2
April	27·7	31·7	23·7	30·1	36·0	24·2	30·7	35·6	25·8	29·3	32·8	25·8	28·1	31·7	24·5
May	27·2	30·4	23·9	30·3	35·3	25·3	32·5	37·3	27·6	29·0	32·3	25·7	29·7	32·8	26·4
June	26·5	29·1	23·9	29·7	33·6	25·9	31·6	36·0	27·2	26·6	29·3	23·9	28·7	31·4	25·9
July	26·4	28·8	23·9	28·7	31·9	25·9	29·1	32·4	25·8	25·7	28·0	23·4	27·2	29·7	24·6
August	26·2	28·6	23·7	28·7	31·7	25·7	28·9	32·1	25·7	25·9	28·3	23·5	27·0	29·4	24·5
September	25·8	28·4	23·2	28·9	32·2	25·6	28·9	32·1	25·6	26·4	29·1	23·7	27·0	29·7	24·3
October	26·0	28·8	23·2	27·5	31·8	23·2	27·7	31·1	24·4	27·0	30·2	23·8	27·9	31·6	24·2
November	26·0	28·8	23·1	23·3	29·0	17·6	25·2	28·4	22·0	27·0	30·7	23·2	27·2	31·9	22·5
December	25·7	28·7	22·7	19·6	26·3	12·8	23·1	26·9	19·1	26·4	30·9	21·8	25·4	30·3	20·4
M. A. T.	26·3	..	..	26·3	..	..	27·9	..	..	27·1	..	..	26·8	..	..
Annual mean maximum	29·4	..	..	31·4	..	..	31·8	..	..	30·6	..	..	30·4	..	..
Highest record	36·1	..	..	42·2	..	..	47·2	..	..	37·2	..	..	38·3	..	..
Annual mean minimum	23·1	..	..	21·2	..	..	23·9	..	..	23·7	..	..	23·2	..	..
Lowest record	16·7	..	..	6·7	..	..	13·9	..	..	16·1	..	..	11·7	..	..
No. of years	60	..	..	60	..	..	60	..	..	60	..	..	60 (to 1940)	..	..

Rainfall.—The rainfall varies greatly without much influence on the vegetation. The West Coast and the Andamans get a high rainfall of over 3,000 mm. whilst the Ganges delta receives about 1,730 mm. and the East Coast only 1,000 mm. Below 260 mm. rainfall is received on the western Saurashtra coast. Humidity is correspondingly high at 80% in the former pair and lower, about 73% in the eastern region.

Rainfall (millimetres)

Tidal Swamp Forests

Month	Andaman Islands PORT BLAIR 80 m.	West Bengal CALCUTTA 6 m.	Andhra Pradesh KAKINADA 8 m.	Andhra Pradesh MASULIPATAM	Kerala TRIVANDRUM	Kerala CALICUT 8 m.	Maharashtra BOMBAY 11 m.	Gujarat PORBUNDAR 5 m.
January . . .	45	9	7	5	20	9	4	3
February . . .	28	30	8	14	19	5	2	3
March . . .	28	35	12	11	39	17	1	2
April	60	45	16	18	115	91	1	..
May	384	140	39	34	223	236	17	5
June	562	297	119	107	335	840	484	113
July	392	325	166	162	197	825	617	210
August . . .	414	328	141	159	120	436	340	95
September . . .	442	253	157	62	115	202	264	31
October	318	114	216	218	273	261	65	7
November . . .	267	21	142	147	177	139	14	8
December . . .	201	5	18	17	63	26	2	3
Total for year . . .	3,143	1,600	1,042	1,053	1,697	3,085	1,809	479
Number of rainy days .	150	84	56	55	97	115	74	24
Number of months less than 50 mm. . . .	3	6	6	6	3	4	7	9
M. A. Humidity . .	81	74	73	74	80	80	74	?
No. of years . . .	60	60	60	60	100	60	60	53

Topography.—A maze of tidal creeks the banks of which tend to be higher than the intermediate ground and so to form depressions in and out of which the tide flows daily, submerging the surface twice daily at one extreme and only at the highest spring tides at the other extreme. When the rivers are in spate, their water is banked up at high tide increasing the depth and reducing the salinity.

Soil.—Entirely river-borne silt, a very fine mud, being loamy where the water is fresh and stiff clay where it is salt, locally with some overlying sand (sometimes blown, sometimes deposited by water).

GENERAL FLORISTICS.—*Rhizophoraceae* are almost confined to the type, and are most typical though absent or inconspicuous over much of the upper levels ; their special habitat is the newly deposited mud banks submerged by the tides every day. In addition there are a few genera, each usually with several species, belonging to a considerable number of families, which are specially adopted to the unusual conditions, thus *Sterculiaceae* (*Heritiera*), *Meliaceae* (*Carapa*), *Lythraceae* (*Sonneratia*), *Verbenaceae* (*Avicennia*), *Euphorbiaceae* (*Excoecaria*), *Apocynaceae* (*Cerbera*), *Leguminosae* (*Cynometra*). Shrubs as opposed to small trees are few, *Acanthus* being the commonest, whilst the fern *Acrostichum aureum* is very typical. Palms are similarly limited to a few species notably *Phoenix paludosa* and *Nipa fruticans*. Actually the flora is a poor one and exceptionally uniform and widespread. Grasses are commonly absent, but *Oryza coarctata* is an early colonist where the water is fairly fresh. Studies have been made comparing the mangrove floras of the main occurrences showing the East Coast to be the richest in species (BLATTER et al.).

SUB-DIVISIONS, SUCCESSIONS, etc.—

The following types are recognized :

*TS*1—Mangrove scrub

*TS*2—Mangrove forest

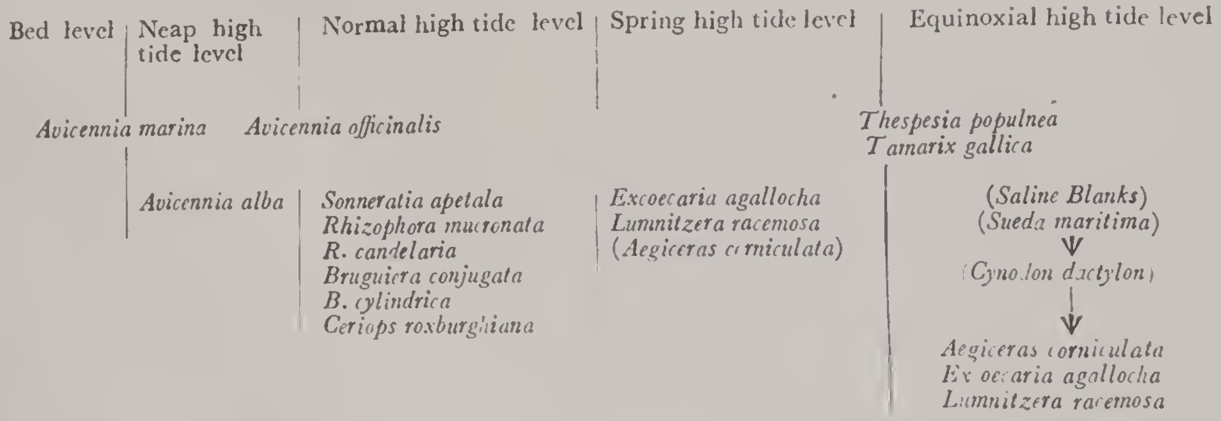
*TS*3—Salt water mixed forest (*Heritiera*)

*TS*4—Brackish water mixed forest (*Heritiera*)

*E*1—Palm swamp.

NOTE.—In the simplest case, there is evidently a succession from the mangrove scrub to forest, and then through salt water to brackish water mixed forest as soil deposition progresses. From this stage there is often retrogression to rather drier types with monsoon flooding only and ultimately to the climatic climax which, though varying very greatly even to thorn scrub in the Indus, is very generally a form of tropical evergreen. WAHEED KHAN (1957) has given a useful summary of information and views on the ecology of the tidal forests.

The succession of vegetation with respect to tidal influence is illustrated below for the Lower Godavari delta.



TS1. Mangrove scrub

NOMENCLATURE.—Salt water forests. (CURTIS).

DESCRIPTION.—More or less dense forest of very low average height, often only 3-6 m. high. Often further reduced by biotic agencies, species few and markedly gregarious; all evergreen with entire leathery leaves. Vivipary usual.

DISTRIBUTION.—In the river deltas along the edge of tidal waterways and on sheltered muddy coasts from Gujarat round to Bengal. It occupies a large proportion of the Western Sunderbans.

LOCALITY FACTORS.—Soft tidal mud submerged by salt water at every tide. In the W. Sunderbans new silt is not being brought down by the rivers but is derived from the scouring of the land surface causing extensive depressions.

FLORISTICS.—

(i) *W. Sunderbans, Bengal* (cf. RAO)—

I/II. *Ceriops roxburghiana**, *Avicennia alba**, *Aegialitis rotundifolia*, *Excoecaria agallocha*, *Phoenix paludosa* (drier ground).

III. *Acanthus ilicifolius*, *Brownlowia lanceolata*.

IVb. Local patches of grass.

NOTE.—This type predominates in the south-western part of the delta. Extensive more or less bare depressions are numerous.

(ii) *Salsette Island, Bombay* (PATIL)—

I/II. *Avicennia alba**, *Sonneratia apetala*, *Excoecaria*, *Aegiceras*, *Avicennia officinalis*.

III. *Acanthus ilicifolius*.

NOTE.—With increasing pressure of biotic factors, the vegetation is progressively reduced to a low cover almost exclusively of *Avicennia alba* and *Acanthus*.

(iii) *Godavari and Krishna deltas*—

*Avicennia officinalis**, *A. marina**, *Excoecaria agallocha**, and *Lumnitzera racemosa* form 90% of the stock.

TS2. Mangrove forest

DESCRIPTION.—Typically a closed evergreen forest of moderate height composed of trees specially adapted to survive on tidal mud which is permanently wet with salt water and submerged every tide. Stilt roots are very typical (notably in *Rhizophora*), so also are leathery entire leaves and vivipary.

DISTRIBUTION.—In the river deltas along the edge of the waterways and sheltered muddy coasts of the East Coast of Bengal and a little on West Coast : also in the Andaman Islands.

LOCALITY FACTORS.—The type is found on the mud banks of the delta streams, the tails of islands, and over more extensive areas near the sea face wherever accretion is in progress. It does not develop on the sandy banks at the sea face. for though some young growth may be found, it passes on to other types without full development in the present one. The ground is flooded daily by salt water and never has time to dry out.

ILLUSTRATION.—Plate 30.

FLORISTICS.—

(i) *W. Sunderbans*—

I/II. *Rhizophora candelaria**, *Kandelia candel*, *Avicennia alba**, *Bruguiera conjugatas*, *Xylocarpus molluccensis* (*Carapa*), *Ceriops tagal**, *Lumnitzera racemosa*, *Xylocarpus granatum*, *Excoecaria agallocha*, *Ceriops roxburghiana*, *Sonneratia apetala*.

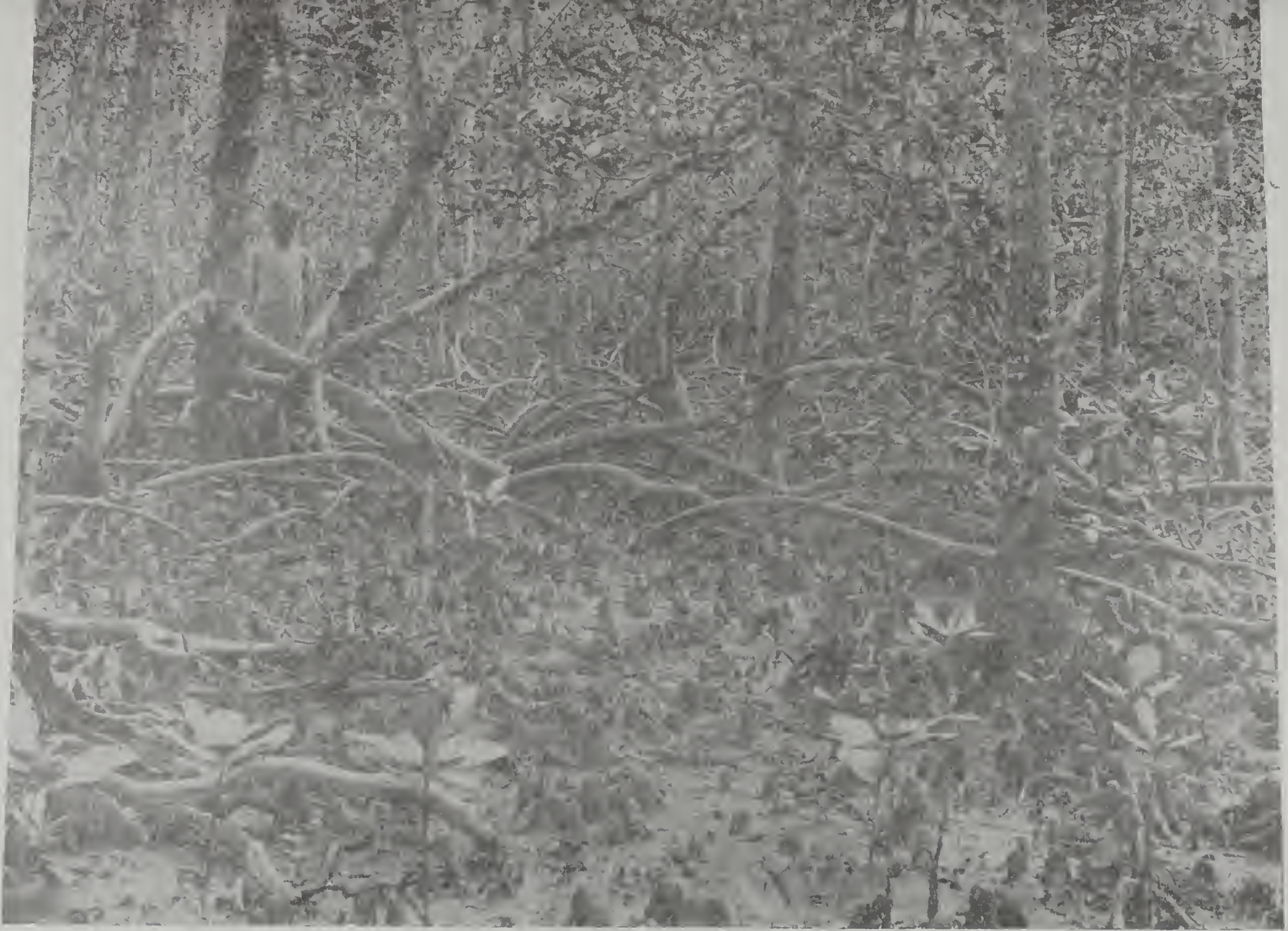
(ii) *Krishna and Godavari deltas* (A.A. KHAN)—

I/II. *Avicennia officinalis**, *Rhizophora mucronata**, *R. candelaria*, *Ceriops roxburghiana**, *Bruguiera* spp., *Sonneratia apetala*.

III. *Acanthus ilicifolius*, *Clerodendrum inerme*.

V. *Dalbergia spinosa*, *Derris trifoliata*.

NOTE.—As the ground level rises *Excoecaria* and *Lumnitzera* take over.



MANGROVE FOREST

Rhizophora mucronata (stilt roots) and *Bruginera gymnorohiza* (knee roots), near Long Island, South Andamans.

H. G. Champion

(iii) *Mahanadi delta* (HAINES)—

Very similar to (ii).

(iv) *Andaman Islands* (CHENGAPPA)—

*Rhizophora mucronata**, *R. candelaria* (outer edge), *Bruguiera conjugata**, *B.parviflora* (just behind), *Avicennia officinalis*, *Ceriops tagal**, *Kandelia candel*, *Xylocarpus molluccensis*, *Sonneratia caseolaris*, *Excoecaria*, etc.

(v) *Great Nicobar Islands* (SAHNI)—

*Bruguiera conjugata**, *Carallia brachiata*, *Sonneratia caseolaris*, *Nipa fruticans*, *Areca triandra*.

General Note.—The soil deposition occurring in this type is mainly the product of erosion higher in the delta. The type appears stable over long periods but must gradually pass into the *Heritiera* as the level is raised unless changes result in fresh erosion or deposition of sand. The *Rhizophoras* and *Sonneratia* form the lowest, outermost fringe and other species mentioned are rather behind and above and probably represent the next seral stage.

TS3. Saltwater mixed forest (Heritiera)

NOMENCLATURE.—Moderately saltwater forests (CURTIS).

DESCRIPTION.—The forest is fairly dense—it may even be denser than the freshwater type next to be described but is never high, rarely over 20 m. nor do the trees attain large girths. The species are fairly numerous but tend to occur gregariously. Stilt roots are infrequent but pneumatophores typical.

DISTRIBUTION.—In the bigger river deltas behind and beyond the foregoing type.

LOCALITY FACTORS.—The type occurs where the ground is flooded every tide with definitely brackish water. There is less silt deposition than in the freshwater type and so the soil has less humus and is less loamy, a stiffer clay liable to crack extensively if exposed.

FLORISTICS.—

(i) *W. Bengal, Sunderbans* (cf. RAO).—

I/II. *Heritiera minor**, *Excoecaria agallocha**, *Ceriops roxburghiana**, *Xylocarpus molluccensis*, *Bruguiera conjugata*, *Avicennia officinalis*, *Amoora cucullata*, *Aegialitis rotundifolia* (la near sea face).

III. *Nipa* relatively uncommon.

Note.—At slightly higher levels, the flooding is less frequent and the salt concentrates with resultant poor forest, typically scattered small *Heritiera*. Tree mangrove forest with the *Rhizophora* occurs in close proximity along the edges of the rivers throughout.

TS4. Brackish water mixed forest (Heritiera)

NOMENCLATURE.—Fresh water forests (CURTIS).

DESCRIPTION.—This is the finest development of the tidal forests and may be a close forest over 33 m. high (*Bruguiera* and *Heritiera*) but it is only poorly represented in the western part of the Sunderbans. Stilt roots are rarely met with but pneumatophores are usual (both genera mentioned).

DISTRIBUTION.—In the larger deltas, notably the Ganges.

LOCALITY FACTORS.—The type occupies the levels which are flooded for some portion of each day, the water never being very salt and during the rainy season either quite fresh or only slightly brackish. There is a good deposit of fresh silt each year. It is best developed on the ground lying between the drier banks of the larger streams and the central *depressions* ("*bils*" in the Sunderbans).

ILLUSTRATION.—Plate 31.

FLORISTICS.—

(i) *W. Bengal, Sunderbans.*—

I. *Heritiera minor**, *Xylocarpus molluccensis*, *Bruguiera conjugata*, *Sonneratia apetala*, *Avicennia officinalis*, *Sonneratia caseolaris.*

II. *Excoecaria agallocha*, *Cynometra ramiflora** (dry soils), *Amoora cucullata** (wet soils), *Ceriops roxburghiana*, *Phoenix paludosa* (high land).

III. *Acanthus ilicifolius*, *Hibiscus tiliaceus*, *Pandanus tectorius*, *Acrostichum aureum* (especially in depressions), *Brownlowia lanceolata*, *Nipa* (fringing banks).

V. *Derris* spp.

(ii) *Andaman Islands* (CHENGAPPA).—

I/II. *Heritiera littoralis**, *Barringtonia racemosa*, *B. asiatica.*

III. *Brownlowia lanceolata*, *Acanthus* spp.

IV. *Phoenix paludosa*, *Nipa.*

E1. Palm swamp

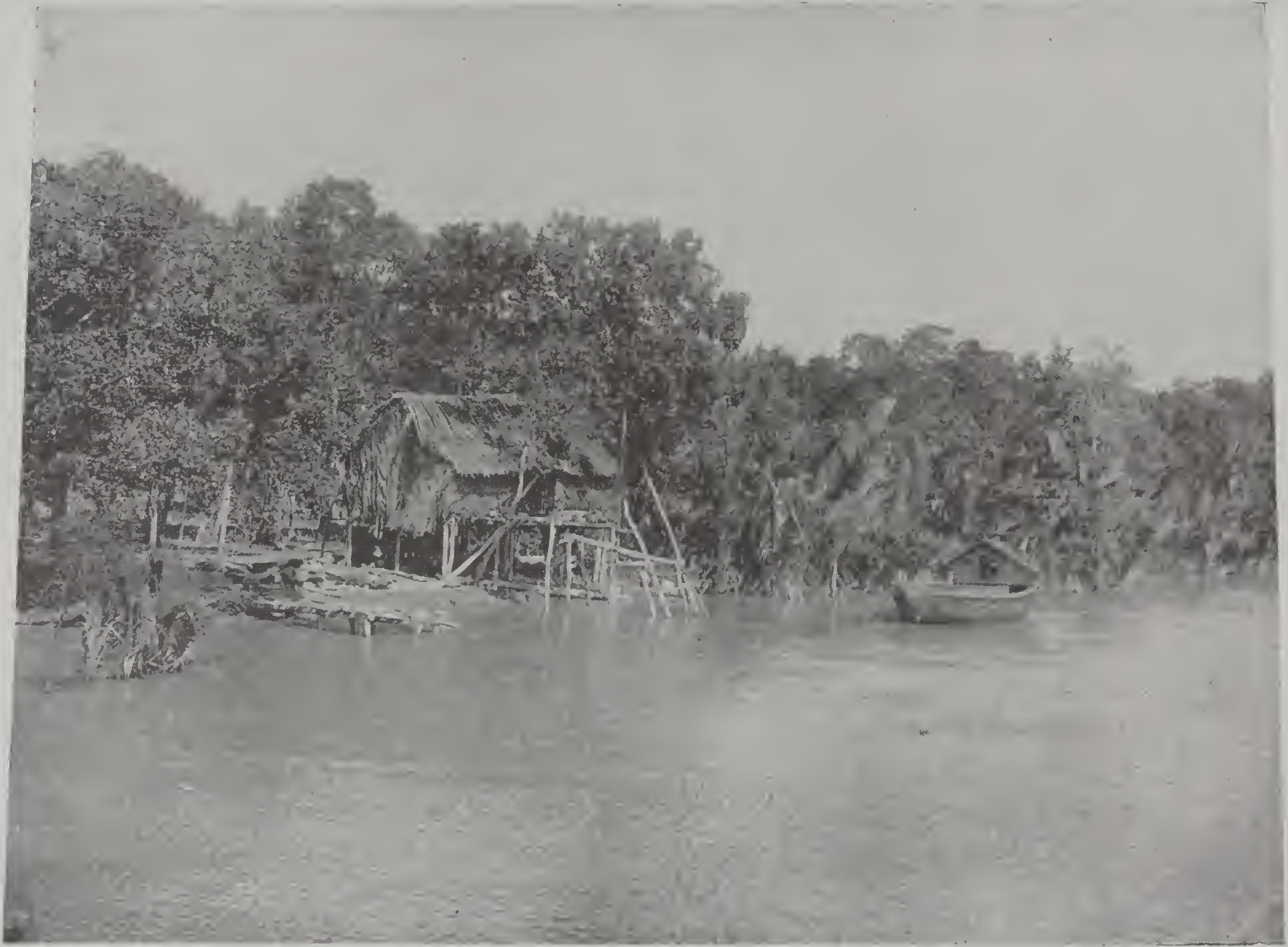
DESCRIPTION.—A dense low growth of tufted palms upto 6 m. high.

DISTRIBUTION.—On the drier areas within the salt water mangrove scrub or forest.

LOCALITY FACTORS.—As above.

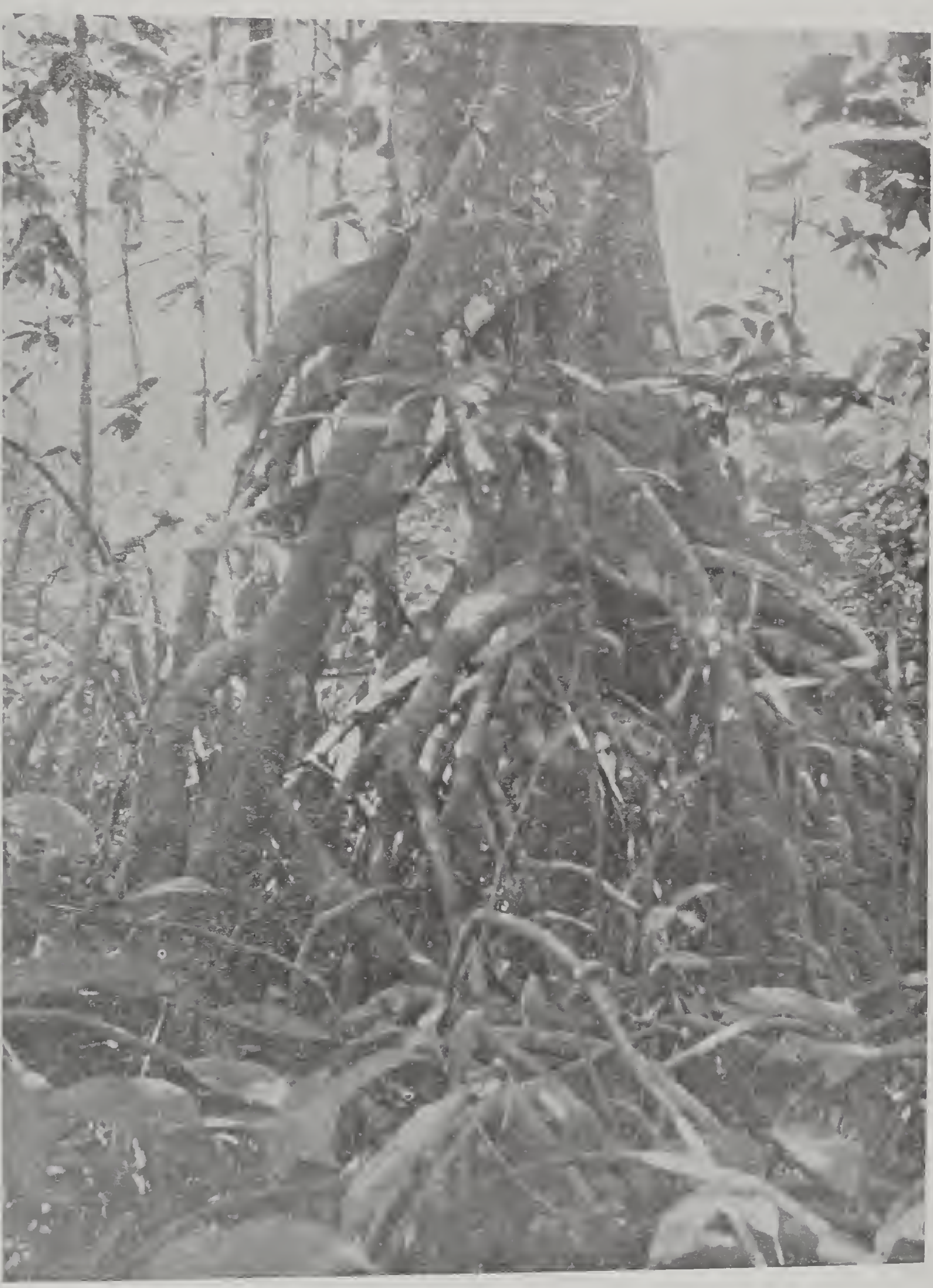
ILLUSTRATION.—cf. Plate 31.

FLORISTICS.—*Phoenix paludosa.*



BRACKISH WATER MIXED FOREST

Heritiera forest under felling operations. *Nipa fruticans* lines the bank. Sunderbans, West Bengal. *H. G. Champion*



MYRISTICA SWAMP FOREST

Large *Myristica magnifica* with typical knee roots. Evergreen swamp, Kerala.

S. K. Seth

Sub-group 4C. Tropical Freshwater Swamp Forests

FS1. Myristica swamp forest

NOMENCLATURE.—*Myristica* swamps (KRISHNAMOORTHY).

DESCRIPTION.—Fairly dense evergreen closed forest about 15—30 m. high, with clean slender boles standing in mud through which abundant knee roots protrude. There is little undergrowth, mainly *Aroids* and *Scitaminae.*

DISTRIBUTION.—Restricted to valleys in the tropical evergreen forests of Travancore, Kerala.

LOCALITY FACTORS.—As fringing forest to sluggish streams below 300 m. altitude. Soil sandy alluvium with high humus content, often over kaolin clay derived from under-lying gneissic rock. Inundated June to January and continuously wet or moist the rest of the year.

ILLUSTRATION.—Plate 32.

FLORISTICS.—(KRISHNAMOORTHY).—

I/II. *Myristica magnifica** (v.a), *M. laurifolia* (o), *M. canarica* (f), *M. malabarica* (o), *Lagerstroemia speciosa* (f), *Lophopetalum wightianum* (o), *Eugenia montana* (o), *Carallia brachiata* (o).

III. *Pandanus* sp.

IVa. *Aroidae*, *Cyperaceae*, *Scitaminae.*

V. *Calamus* sp.

NOTE.—This localised but interesting type recently described from Kerala is being rapidly destroyed for conversion into paddy fields.

Similar forest is recorded from New Guinea (WOMERSLEY, 1957).

FS2. Tropical hill valley swamp forest

DESCRIPTION.—Irregular forest of a limited number of mainly evergreen species able to withstand the wetness of the sites occupied. The trees are usually low-crowned and branchy and there is often a dense growth of *Calamus*, whilst *Ficus* and monocotyledons such as *Alpinia* often form the undergrowth

DISTRIBUTION.—In suitable sites all along the Himalayan sub-montane tract and in tropical hill valleys though most of it has been cleared and drained for agriculture.

LOCALITY FACTORS.—As compared with the preceding type, the water is moving and presumably well aerated. The stream beds are usually gravelly and the silt and sand in which the trees are rooted are usually richly humic. The site is continuously wet or at least moist.

ILLUSTRATION.—Plate 33.

FLORISTICS.—

(i) *Near Gudalur, Nilgiri, Wynaad, Kerala.*—

I. *Eugenia** spp. (a), *Mallotus albus** (a).

III. *Pandanus* sp. (a).

IV. *Alpinia* spp. (va).

NOTE.—Narrow strips only.

(ii) *Near Manantoddy, Wynaad Division, Kerala.*—

I. *Anthocephalus cadamba** (a), *Machilus macrantha* (f), *Elaeocarpus tuberculatus** (f).

III. *Pandanus* sp. (a).

IV. *Alpinia* sp. (va).

NOTE.—These forms with *Pandanus* and *Alpinia* are very typical of the narrow swampy hollows in the W. Ghats.

(iii) *Golatappar, Dehra Dun, U. P.*—

I. *Ficus glomerata** (D), *Trewia nudiflora** (D), *Syzygium cumini* (E), *Pterospermum acerifolium* (E), *Cedrela toona* (D), *Bischofia javanica** (E).

II. *Diospyros peregrina** (E), *Carallia brachiata* (E), *Putranjiva roxburghii* (E), *Phoebe lanceolata* (E), *Machilus gamblei* (E), *Salix tetrasperma.*

III. *Acronychia pedunculata, Ardisia solanacea, Desmodium laburnifolium*

IVa. Ferns but no grass.

V. *Calamus tenuis.*

NOTE.—A gravelly soil with perennial running water.

FS3. Creeper swamp forest

NOMENCLATURE.—Swamp and creeper forest (BOR).

DESCRIPTION.—Thick impenetrable forest about 10 m. in height, the trees supporting a mass of creepers by which they are almost completely overgrown, surrounded by high forest containing pockets of *Phragmites* themselves including patches of *Cephalanthus.*

DISTRIBUTION.—Low-lying sites in the Brahmaputra Valley.

LOCALITY FACTORS.—At 150—200 m., soil heavy, very moist and low-lying, 1·5—2 m. deep over bhabar gravel.

FLORISTICS.—(BOR).—

I. *Magnolia griffithii, Litsea* spp., *Quercus listeri, Drimycarpus racemosus, Altingia.*

II. *Machilus gamblei, Syzygium cumini, Eugenia formosa, Vatica lanceaefolia.*

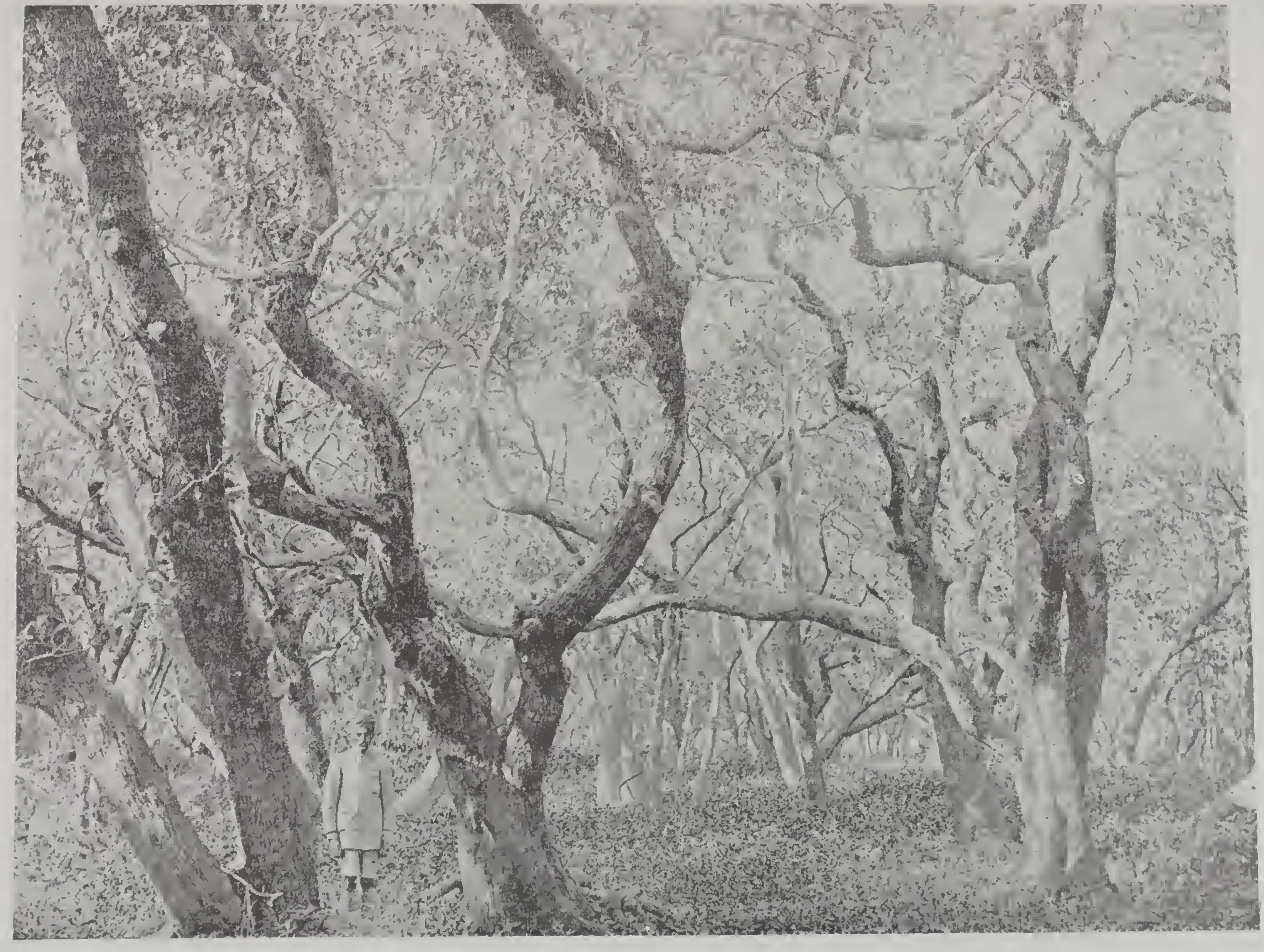
V. *Calamus leptospadix, C. tenuis, Cissus, Uncaria, Acacia, Toddalia,* etc.

BOR enumerates 50 species as commonly found in this t pe.

SUBMONTANE HILL VALLEY SWAMP FOREST

Trewia nudiflora, Syzygium cumini, Ficus glomerata, Cedrela toona and *Bischofia javanica* with *Calamus tenius.*

Dauli Khatta, Haldwani Division, Uttar Pradesh. *A. E. Osmaston*



BARRINGTONIA SWAMP FOREST
Barringtonia acutangula with no regeneration but *Syzygium cumini* covering the ground.
Katharia nadi, S. Kheri Division, Uttar Pradesh.

A. E. Osmaston

Sub-group 4D. Tropical Seasonal Swamp Forests

SUBDIVISIONS.—

The following types have been distinguished:

SS1	*Eastern seasonal swamp forest.*
SS2	*Barringtonia swamp forest.*
SS3	*Syzygium cumini swamp forest.*
SS4	*Eastern seasonal swamp low forest (Cephalanthus).*
SS5	*Eastern Dillenia swamp forest.*
2*S1*	*(Syzygium parkland).*
2*S2*	*(Eastern wet alluvial grassland).*

SS1. Eastern seasonal swamp forest

NOMENCLATURE.—*Altingia-Machilus-Syzygium hylis* (BOR).

DESCRIPTION.—An unusually even and dense forest with the canopy at about 20 m. almost impenetrable on account of the canes. (BOR).

DISTRIBUTION.—Apparently restricted to limited areas in the Brahmaputra Valley.

LOCALITY FACTORS.—"The soil, which is under water for the greater part of the rains, is black and formed by very finely divided material. Fire does not penetrate."

FLORISTICS.—(BOR).—

I/II. *Altingia excelsa** (70%), *Machilus gamblei** (25%), *Syzygium cumini**, *S. cerasoideum*, *Elaeocarpus varunna*, *Michelia doltsopa*, *Cinnamomum* spp., *Litsea* spp., *Turpinia* spp., etc.

IIa. *Pinanga gracilis.*

III. *Psychotria, Clerodendrum, Allophylus, Laportea.*

IVa. Ferns abundant.

V. *Calamus tenuis, C. latifolius.*

SS2. Barringtonia swamp forest

DESCRIPTION.—The type normally consists of a rather open crop of evergreen trees of medium height (generally 10-20 m.) and of but few species, often pure crops, but it may be much denser and with or without a thick undergrowth likewise of evergreen species. Some of the ground, particularly the rather higher parts, may be under coarse savannah grass which may be of secondary origin and indistinguishable from the grass savannah of the alluvial succession. Climbers are few though *Calamus* may be abundant. The flora is specialised and poor in species. The luxuriance of the vegetation varies greatly with conditions and the extent of human interference from a very open crop of low trees over grass to a dense closed canopy. Subdivision is probably desirable.

DISTRIBUTION.—India is devoid of extensive permanent swamps particularly in the southern parts, but there are a good many tracts which are under water continuously for a fairly long period during the rains. The Ganges-Brahmaputra Valley has many such areas some of which are former river beds. The extensive swampy tracts that must once have been present at the head of the Ganges delta have all been cleared.

LOCALITY FACTORS.—The most important factor is the often prolonged annual summer flood; where the flooding is too deep and prolonged, tree growth may be unable to establish itself so that until the level is raised by siltation only grassland occurs (cf. p. 172). Between the flood periods the soil dries out to a varying extent, and where it is heavy and retentive the available water supply may be scanty resulting in poor growth. Soil aeration is usually poor and the soil is rich in humus partly from this reason; soil temperatures must also be lower than in the adjoining drier types. Rainfall is relatively unimportant except indirectly but usually exceeds 1,250 mm and the water table never falls below 4-5 m. and more usually not more than a metre or two.

ILLUSTRATION.—Plate 34.

FLORISTICS.—

(i) *Katna river, S. Kheri, Uttar Pradesh.* (WORKING PLAN).—

I/II. *Barringtonia acutangula**, *Syzygium cumini*, *Salix tetrasperma*, *Pongamia pinnata*, *Streblus asper*, *Ficus glomerata*.

III. *Ardisia solanacea* etc.

V. *Calamus tenuis*.

(ii) *Sonebheel, Cachar, Assam.*—

I. *Barringtonia acutangula**.

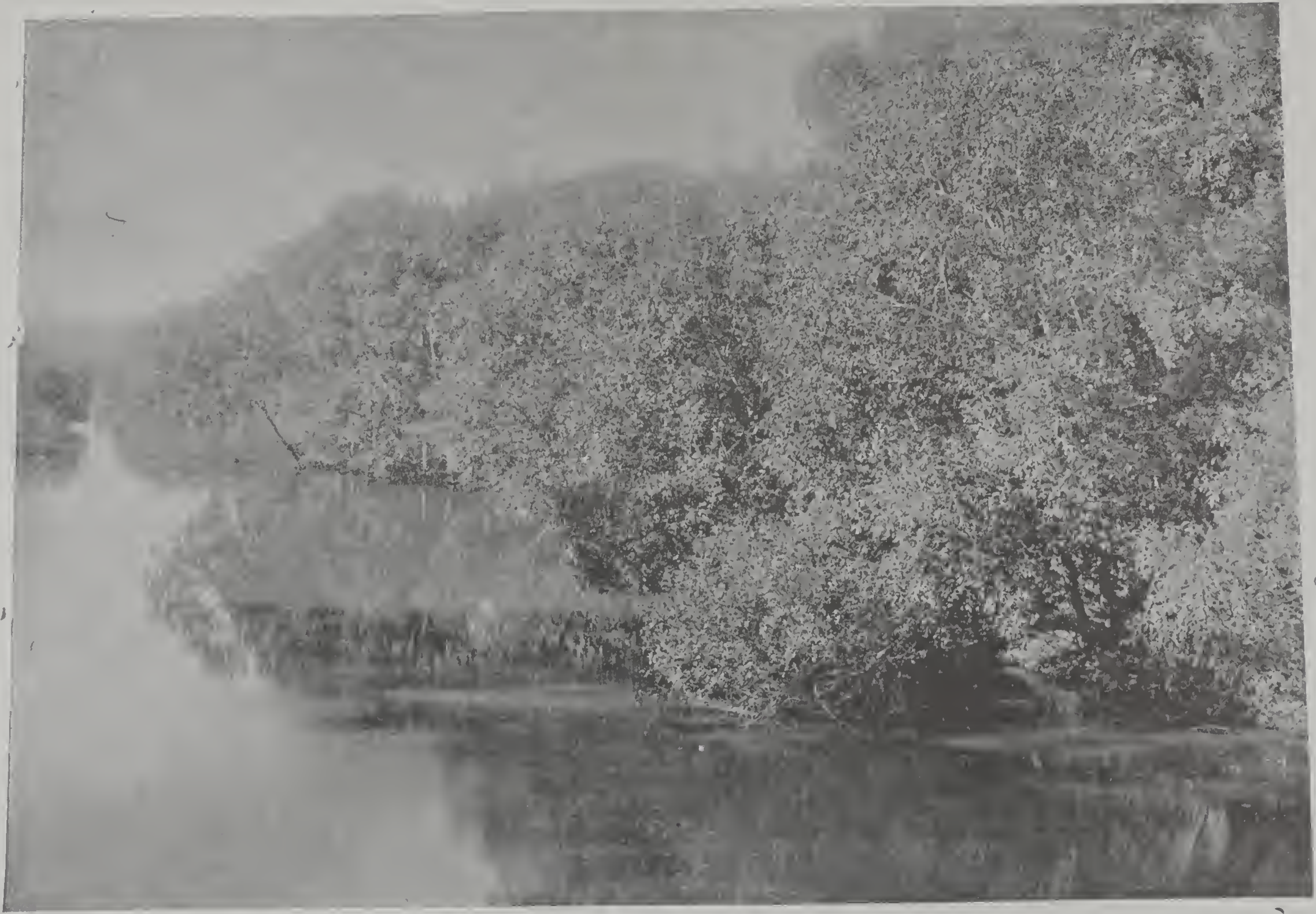
NOTE.—*Barringtonia* may form an almost pure crop, sometimes with a nearly closed canopy, examples occurring in all the States forming the Ganges-Brahmaputra alluvial plain.

SS3. Syzygium cumini swamp forest

NOMENCLATURE.—*Jamun* belts.

DISTRIBUTION.—Along stream banks in Gangetic alluvium, typically seen in Eastern U.P.

DESCRIPTION.—A remarkably pure forest usually a narrow belt but sometimes much wider, spreading over low flats and shallow depressions. The stands are dense with long clean slender boles. There is no undergrowth.



SYZYGIUM CUMINI SWAMP LOW FOREST

Typical stand of *Syzygium* along the marshy banks of a stream. Gorakhpur Division, Uttar Pradesh.

T. B. Chitrakar

7 FRI&C/64.]

LOCALITY FACTORS.—Low lying, seasonally flooded, ground along the banks of sluggish streams.

ILLUSTRATION.—Plate 35.

FLORISTICS.—

I. *Syzygium cumini.*

NOTE.—*Barringtonia* may sometimes form consociation with the *Syzygium*. Occasionally *Trewia nudiflora* and at the water's edge, *Salix tetrasperma* also occur.

SS4. Low swamp forest (Cephalanthus)

DESCRIPTION.—A shrubby formation some 5 m. high with a few stunted *Shorea robusta* etc.

DISTRIBUTION.—In the Gangetic Valley from Pilibhit (U.P.) eastwards; common in Brahmaputra Valley.

LOCALITY FACTORS.—Swampy depressions in the sal zone where a very deep black heavy waterlogged soil has been formed.

FLORISTICS.—

(i) *Brahmaputra Valley, Assam*—

I. *Shorea robusta* (o).

II. *Cephalanthus occidentalis**, *Glochidion hirsutum**.

III. *Melastoma malabathricum.*

IV. *Alpinia* spp., *Canna indica, Clinogyne dichotoma.*

IVa. *Phragmites karka**, *Saccolepis interrupta, Leersia hexandra.*

(ii) *South Kheri Division, U.P.*—

I. *Syzygium cumini**.

II. *Cephalanthus occidentalis**.

III. *Glycosmis pentaphylla.*

SS5. Eastern Dillenia swamp forest

NOMENCLATURE.—Inundation forest (RAJKHOWA).

Dillenia-Bischofia and *Dillenia-Mesua* subtypes.

DESCRIPTION.—A fairly dense forest of medium height with many evergreen and semi-evergreen species.

DISTRIBUTION.—Throughout the evergreen and semi-evergreen zones in Assam extending several miles from the main rivers.

LOCALITY FACTORS.—The type occurs on heavy (*khurkani*) soils on flat topography flooded during the wet seasons but drying out between.

FLORISTICS.—

(i) *Dillenia-Bischofia subtype*—3 localities (RAJKHOWA)—

I. *Dillenia indica** (22-26%), *Bischofia** (13-26%), *Albizzia lucida* (2-4%), *Lagerstroemia* (3-9%), *Terminalia chebula* (2%).

II. *Eugenia* spp. (1-3%), *Vatica lanceaefolia* (6-19%).

Percentages are for trees over 3 ft. girth in Jokai, Telpani and Dehingmukh Reserves.

(ii) *Dillenia-Mesua-Altingia subtype*—2 localities (RAJKHOWA).—

I *Mesua** (13-31%), *Dillenia** (6-9%), *Altingia** (3-22%), *Artocarpus chaplasha* (1%), *Bischofia* (1-5%), *Castanopsis indica* (1-4%), *Canarium* (1-4%), *Magnoliaceae* (1-3%).

II. *Eugenia* spp. (2-4%), *Premna bengalensis* (1-2%), *Turpinia* (0-8%), *Vatica* (1-3%).

Percentages are for trees over 3 ft. girth in Namdang and Belipara Reserves.

2S1. (Syzygium parkland)

This is described under 2/1S2. page 96.

2S2. (Eastern wet alluvial grassland)

Mention may be made here of the treeless grasslands occurring in cut-off meanders of the main rivers and similar low alluvial sites. These are deeply flooded (3-4 m.) during the monsoon but the stiff ("*khurkani*" in Assam) soil dries out completely during the hot weather. This alternation appears to be too severe for tree growth and presumably the grassland formation will remain until slow siltation has raised the level considerably. In most cases, fire runs through the grass annually, being the more destructive the later it occurs, almost stopping the progression that could otherwise take place; the type is thus to be viewed as an early arrested stage of a primary sere.

ILLUSTRATION.—Plate 36.

FLORISTICS.—

(i) *Tarai swamp grassland* (AGRAWAL).—

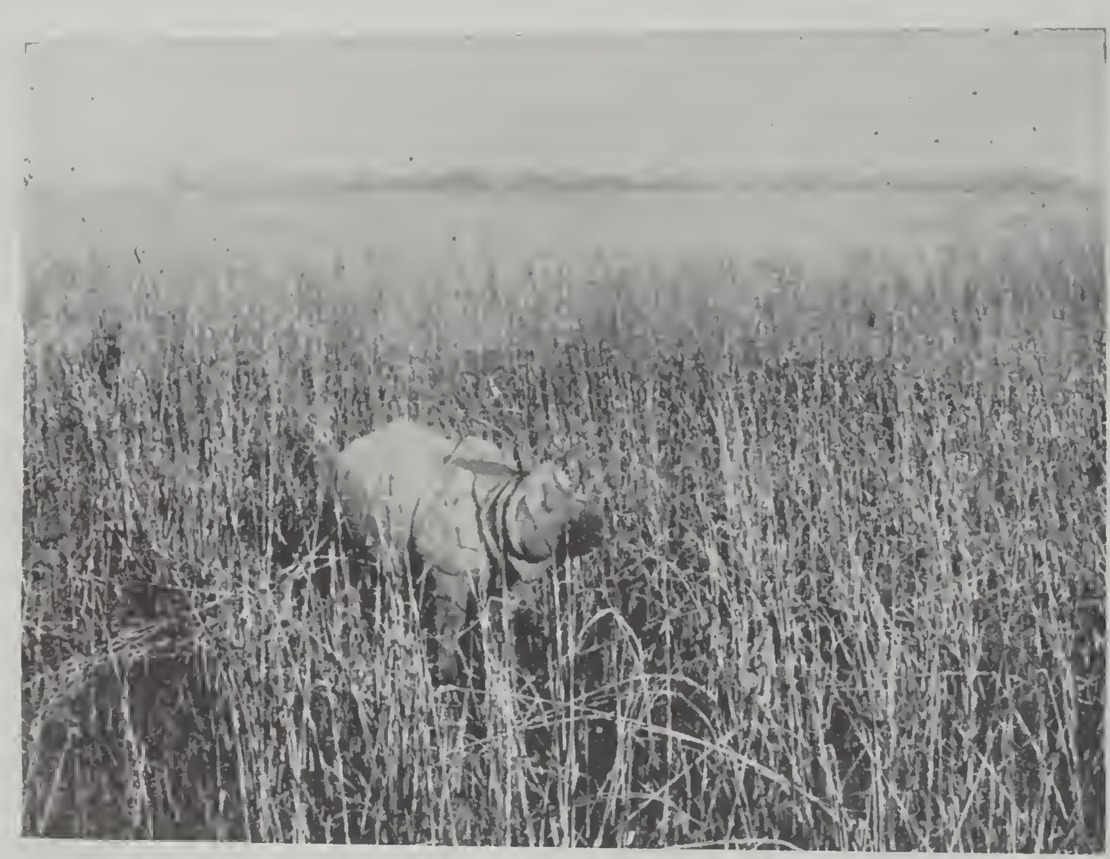
Vetiveria zizanioides, Erianthus arundinaceus, E. munja, Phragmites karka, Themeda arundinacea, Sclerostachya fusca at times as tall as 6 m.

(ii) *Reed swamp, Uttar Pradesh* (SETH)—

Phragmites karka, Arundo donax, Typha elephantina, Saccharum spontaneum, Imperata cylindrica, Vetiveria zizanioides, Sclerostachya fusca, Coix gigantea, Chionachne koenigii, Erianthus ravennae, Narenga porphyrocoma, Themeda arundinacea (on slightly higher permanently moist ground).

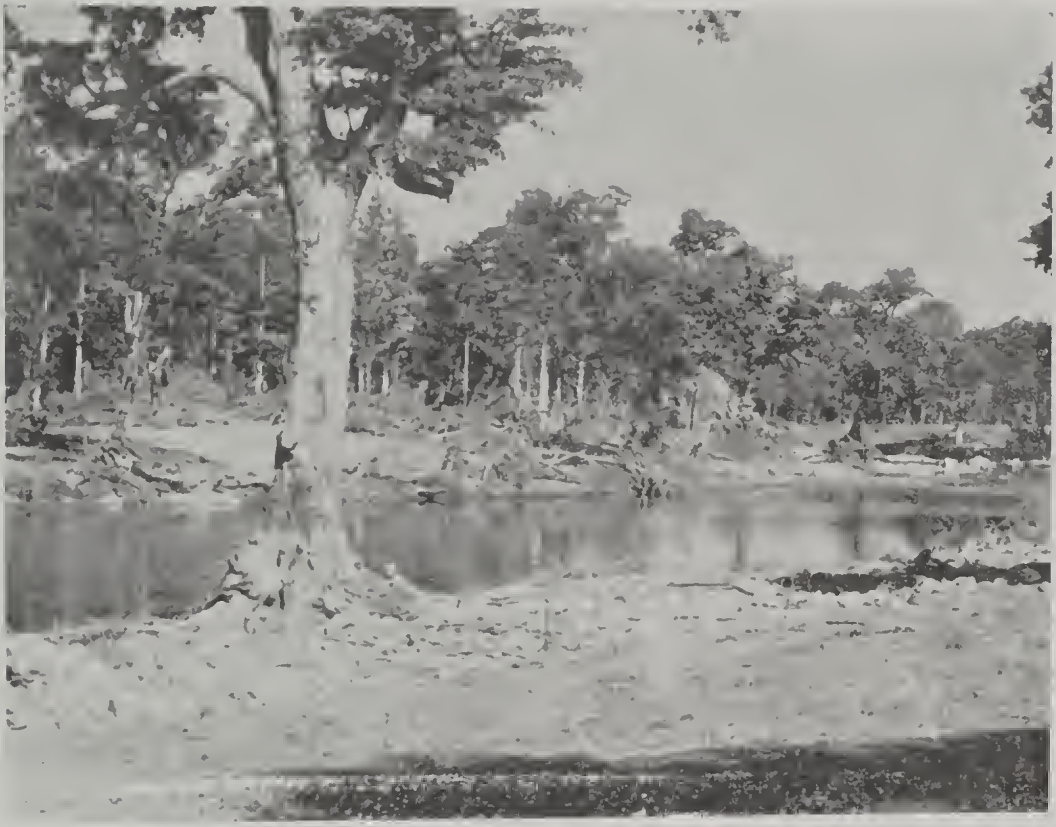
(iii) *Jaldapara Sanctuary, W. Bengal.*—

Saccharum spontaneum, S. procerum, Erianthus arundinaceus, Narenga porphyrocoma, Phragmites karka, Arundo donax.



EASTERN WET ALLUVIAL GRASSLAND
Dense *Phragmites karka* swamp, Kaziranga Wild Life Sanctuary with *Rhinoceros unicornis*), Assam.

H. G. Champion



RIPARIAN FRINGING FOREST

Terminalia arjuna along Machena river, Betul Division, Madhya Pradesh.

H. G. Champion

(iv) *Malda Division, W. Bengal.*—

I. *Barringtonia acutangula* (few, scattered).

IVb. *Saccharum spontaneum, Vetiveria zizanioides, Themeda arundinacea, Aristida* spp., *Phragmites karka,* sedges.

(v) *Kaziranga Game Sanctuary, Assam.*—

Phragmites karka (a), *Saccharum procerum* (a).

NOTE.—The grasses are upto 5 m. high and very dense.

Sub-group 4E. Tropical Riparian Fringing Forests

RS1. Riparian fringing forest

DESCRIPTION.—A few species of large trees typically forming a rather narrow fringe along the water courses sometimes spreading out along the bigger rivers. These trees may be evergreen or deciduous but are usually sub-evergreen. They stand widely spaced with smaller trees and shrubs between and often much coarse grass. Examples are *Bischofia javanica, Terminalia arjuna, T. myriocarpa, Lagerstroemia speciosa.*

DISTRIBUTION.—Along the banks of most of the largest streams in the hilly tracts.

LOCALITY FACTORS.—Ample water supplies are available though the soil may be coarse and non-retentive. The soil is typically sandy; it may be silty but is rarely clayey. It is liable to erosion and temporary flooding, but is normally well drained.

ILLUSTRATION.—Plate 37.

FLORISTICS.—

(i) *Central India.*—

Terminalia arjuna.*

(ii) *Assam, Mysore.*—

Lagerstroemia speciosa.*

GENERAL NOTE.—The type is maintained by the constant erosion and redeposition of soil going on along the rivers. In S. India the form described as Dry tropical riverain (cf. p. 221) is more characteristic, but adequate descriptions are wanting.

CHAPTER VII

DRY TROPICAL FORESTS

GROUP 5. TROPICAL DRY DECIDUOUS FORESTS

Sub-group 5A. Southern Tropical Dry Deciduous Forests

1. NOMENCLATURE

The following terms have been used for forests comprised in this group :

Maharashtra	Dry deciduous forest (Working Plans). Savannath forest (TALBOT). Teak pole forest (Working Plans). *Hardwickia* forest (Working Plans).
Madhya Pradesh and Andhra Pradesh	Dry mixed forest with teak (Working Plans). Dry mixed forest without teak (Working Plans).
Madras and Mysore	Dry mixed deciduous forest. Red sanders forest. Sandal bearing scrub forest.

2. GENERAL DESCRIPTION

The upper canopy in the climax type is a closed though usually rather uneven and not very dense one. It is formed by a mixture of trees practically all of which are deciduous during the dry season, usually for several months, though some for a short period only. Most of the species also occur in the moist deciduous forest where they reach finer development, there, the height of the dry deciduous forest being typically 13-20 m. The number of species is much less than in the foregoing types and although a few tend to predominate over any selected area, the majority are not particularly gregarious so that more or less pure associations can usually be traced to soil peculiarities or human interference. At the same time, the dry deciduous forests provide the clearest examples in tropical India outside the sal forest of natural single species crops. The lower canopy is likewise almost entirely deciduous as although evergreens or sub-evergreens are present they are inconspicuous and mainly confined to the moister and more sheltered spots. An undergrowth of shrubs is usually present but enough light gets in to permit of more or less grass growth, and with burning this tends to become more strongly developed resulting in savannah or park like forms. Bamboos are often present but are not luxuriant. Canes and palms are absent. Climbers are comparatively few but include large woody species which may be locally conspicuous. Epiphytes and ferns are quite inconspicuous.

3. DISTRIBUTION

The type is met with throughout the Indian Peninsula, with the exception of the W. Ghats where the rainfall exceeds 1,900 mm. It merges into thorn forest wherever the rainfall drops below 750 in. as in a large tract to the lee of the W. Ghats. It is thus encountered in Madhya Pradesh, Gujarat, Maharashtra, Andhra Pradesh, Mysore and Madras.

4. LOCALITY FACTORS

Temperature.—Representative localities in the dry deciduous tracts in different parts of the country are included in the attached table. The annual mean maximum lies between 29°C and 35°C and the annual mean minimum between 18°C and 23°C. The highest summer temperature may be as high as 48°C.

Rainfall and humidity.—The typical annual rainfall for the type is 1,000 to 1,300 mm. occasionally down to 850 mm. and frequently up to a much higher figure, say 1,900 mm. on dry soils or rapidly drained sites. A long dry season is experienced with little or no rain for about six months from November or December to April or May and only unimportant showers till the break of the monsoon in June. The mean annual humidity varies considerably, 57 being a typical figure for Upper India, from anything down to 50 in C. India, to figures well over 60 near the W. Ghats, and lower Gangetic plain. Data are given for the same stations as selected for the temperature table.

Rock and soil.—The type is developed on virtually any variety of rock or soil, the latter being naturally dry most of the year. It is especially characteristic of sandy soils, and of lateritic and shallow clay soils and is often found on these even with a rainfall amply sufficient for the moist deciduous type. VAHID's (1927) account of the correlation between geology and forest type in N. Chanda Division of Maharashtra is a useful contribution to our understanding of this type.

Topography.—The greater part of the area under dry deciduous forest is undulating ground, generally hills of low or medium height, but this is largely due to the fact that the flat ground has been brought under cultivation except where pronouncedly unfavourable soil conditions have prevented it. In C. India much of the tract occupied is on the plateaux at 450 m. to 600 m.

5. GENERAL FLORISTICS

The forests can be divided into two classes according as teak is present or absent. The most characteristic tree of the teak-bearing type is *Tectona grandis* and its most typical associates *Anogeissus latifolia* and *Terminalia*. In the non-teak bearing forests, the dominant genera are again *Anogeissus* and *Terminalia* accompanied by *Diospyros*, *Boswellia* and *Sterculia*. Representatives of many families are included among the codominants, their chief characteristic being perhaps their wide distribution and general adaptability such that most are equally common in the cooler northern forest and in the moist deciduous types. *Dipterocarpaceae* are virtually absent (only *Shorea talura* and *S. tumbuggaia* very locally). The chief bamboo is *Dendrocalamus strictus*. The grasses are forms of medium height, *Heteropogon*, *Themeda*, *Saccharum spontanum* etc., the tall tufted *Erianthus*, etc., not occurring.

Temperature data (*centigrade*)

Southern Tropical Dry Deciduous Forests

Month	Bihar HAZARIBAGH 611 m.			Bihar GAYA 111 m.			Orissa SAMBALPUR 148 m.			Madhya Pradesh INDORE 555 m.			Madhya Pradesh JABALPUR 393 m.		
	Mean	Mean max.	Mean min.	Mean	Mean max.	Mean min.	Mean	Mean max.	Mean min.	Mean	Mean max.	Mean min.	Mean	Mean max.	Mean min.
January	16·4	22·7	10·2	23·5	16·6	9·6	20·2	27·7	12·8	18·2	26·4	9·9	17·1	25·2	8·8
February	18·7	25·1	12·3	26·3	19·0	11·6	22·7	30·2	15·2	19·8	28·4	11·3	19·0	27·4	10·6
March	24·1	30·9	17·3	33·2	25·2	17·3	27·4	35·4	19·3	24·6	33·4	15·7	24·0	33·1	14·9
April	29·2	36·2	22·1	38·8	30·7	22·6	31·7	39·4	30·8	29·3	37·6	21·0	29·2	38·1	20·2
May	30·8	37·4	24·2	40·3	33·4	26·6	34·4	41·4	27·3	32·0	39·4	24·6	31·8	40·8	22·7
June	29·2	33·9	24·5	37·5	32·4	27·4	31·7	36·4	26·9	29·8	35·3	24·3	31·3	36·7	25·9
July	26·4	29·6	23·3	33·4	29·7	25·9	27·9	30·7	25·1	26·1	29·5	22·7	27·0	30·2	23·7
August	25·9	28·9	22·9	32·2	28·9	25·7	27·7	30·4	24·9	25·0	28·1	21·9	26·2	29·2	23·1
September	25·8	29·3	22·4	32·5	28·8	25·1	28·2	31·5	24·9	25·4	29·7	21·1	26·5	30·6	22·4
October	23·9	28·7	19·2	32·4	26·3	21·8	26·8	31·6	21·9	24·4	31·5	17·4	24·3	31·0	17·5
November	19·7	25·3	14·0	27·4	20·7	13·9	22·6	28·8	16·3	20·7	28·8	12·6	19·6	27·9	11·3
December	16·2	22·4	10·0	23·7	16·4	9·2	19·4	26·8	12·1	18·2	26·5	9·8	16·6	25·1	8·1
M. A. T.	23·7	..	..	25·7	..	..	26·7	..	..	24·4	..	..	24·5	..	..
Annual mean maximum	29·2	..	..	31·7	..	..	32·5	..	..	31·2	..	..	31·3	..	..
Highest record	43·9	..	..	47·2	..	..	47·2	..	..	45·6	..	..	46·1	..	..
Annual mean minimum	18·1	..	..	19·7	..	..	20·9	..	..	17·7	..	..	17·6	..	..
Lowest record	2·2	..	..	4·4	..	..	4·4	..	..	—2·8	..	..	0		..
No. of years	63	..	..	60	..	..	60	..	..	60 (to 1940)	..	..	60 (to 1940)	..	..

Temperature data (centigrade)—contd.

Month	Madhya Pradesh RAIPUR 296 m.			Maharashtra DOHAD 333 m.			Maharashtra NAGPUR 312 m.			Andhra Pradesh AURANGABAD 306 m.			Andhra Pradesh WARANGAL 269 m.		
	Mean	Mean max.	Mean min.	Mean	Mean max.	Mean min.	Mean	Mean max.	Mean min.	Mean	Mean max.	Mean min.	Mean	Mean max.	Mean min.
January	20·4	27·6	13·2	20·1	28·9	11·1	21·5	28·7	14·3	21·5	29·3	13·7	23·1	29·4	16·6
February	22·3	30·0	14·5	22·0	30·4	13·6	23·9	31·2	16·6	23·4	31·4	15·3	25·4	31·9	18·8
March	27·6	35·1	20·0	26·2	34·6	17·7	28·3	35·9	20·7	27·4	37·5	19·4	28·7	37·6	21·8
April	32·0	39·3	24·6	31·0	38·6	23·4	32·7	40·3	25·1	30·8	32·5	23·2	31·6	25·2	25·1
May	34·8	41·8	27·8	32·7	39·4	25·9	35·4	42·6	28·2	31·1	39·7	24·3	33·9	40·3	27·6
June	31·4	36·6	26·2	31·1	36·2	25·8	32·0	37·5	26·4	28·7	34·6	22·8	31·3	36·3	26·4
July	27·2	30·4	23·9	27·4	30·7	24·1	27·7	31·3	24·2	25·8	30·0	21·6	27·7	31·2	24·3
August	26·8	29·9	23·8	26·6	29·6	23·8	27·3	30·7	23·9	25·1	29·3	20·9	27·2	30·4	23·9
September	27·6	31·2	23·9	26·4	30·8	22·7	27·9	32·1	23·7	25·4	30·1	20·7	27·7	31·2	23·6
October	26·2	31·4	20·9	26·6	33·8	19·4	26·7	32·8	20·6	25·7	32·1	19·4	26·8	31·9	21·6
November	22·3	28·7	15·9	23·2	31·7	14·6	23·2	29·7	16·6	22·9	30·1	15·7	23·7	29·6	17·8
December	19·6	26·7	12·5	20·4	29·1	11·7	20·8	27·6	14·0	20·9	28·6	13·2	22·1	28·4	15·7
M. A. T.	..	..	..	26·1	..	..	27·3	..	..	25·8	..	..	27·4	..	..
Annual mean maximum	32·4	..	..	32·8	..	..	33·4	..	..	32·4	..	..	32·9	..	..
Highest record	47·2	..	..	45·0	..	..	47·8	..	..	45·6	..	..	46·7	..	..
Annual mean minimum	20·7	..	..	19·5	..	..	21·2	..	..	19·2	..	..	21·9	..	..
Lowest record	3·9	..	..	0·0	..	..	3·9	..	..	2·2	..	..	8·3	..	..
No. of years	60 (to 1940)	..	..	10	..	..	60	..	..	50	..	..	40	..	..

Temperature data (centigrade)—concld.

Month	Andhra Pradesh CUDDAPAH 130 m.			Mysore BELGAUM 780 m.			Mysore BANGALORE 921 m.			Madras SALEM 278 m.			Madras TIRUCHIRAPALLI 78 m.		
	Mean	Mean max.	Mean min.	Mean	Mean max.	Mean min.	Mean	Mean max.	Mean min.	Mean	Mean max.	Mean min.	Mean	Mean max.	Mean min.
January	24·9	31·2	18·7	21·6	28·8	14·3	20·4	26·8	14·1	24·8	31·2	18·3	25·4	30·7	20·1
February	27·8	34·6	20·9	23·2	31·3	15·2	22·7	29·8	15·6	26·7	33·9	19·4	27·1	33·4	20·7
March	31·3	38·3	23·8	25·9	34·2	17·6	25·2	32·4	18·1	29·3	36·7	21·9	29·6	36·2	22·8
April	33·8	40.4	27·2	27.1	34·0	20·2	26·9	33·2	20·6	31·3	37·9	24·7	31·8	38·1	25·6
May	34·7	40·9	28·4	27·1	34·0	20·2	26·7	32·9	20·5	31·2	37·4	25·0	32·4	38·6	26·2
June	32·3	37·7	26·9	23·9	27·6	20·2	24·2	29·1	19·3	29·5	35·4	23·8	31·6	37·1	26·1
July	30·5	35·3	25·6	22·1	24·6	19·7	23·1	27·4	18·7	28·6	33·9	23·3	30·9	36·1	25·7
August	30·1	34·8	25·3	22·0	24·7	19·3	23·1	27·4	18·7	28·2	33·5	22·9	30·4	35·8	25·1
September	29·5	34·2	24·7	22·6	26·3	18·7	23·2	27·8	18·5	28·0	33·2	22·8	27·1	35·2	24·6
October	27·9	32·1	23·6	22·8	28·6	17·1	22·9	27·6	18·3	27·2	32·1	22·2	28·4	33·0	23·7
November	26·0	30·9	21·1	22·3	28·2	16·4	21·4	26·3	16·5	25·6	30·6	20·7	26·5	30·6	22·4
December	24·4	30·0	18·7	21·2	27·8	14·7	20·1	25·7	14·6	23·6	28·4	18·8	25·3	29·7	20·9
M. A. T.	..	..	..	23·5	..	..	23·3	..	..	27·9	..	..	29·1	..	..
Annual mean maximum	35·2	..	..	29·3	..	..	28·9	..	..	33·8	..	..	34·6	..	..
Highest record	46·1	..	..	40·6	..	..	38·9	..	..	42·8	..	..	43·9	..	..
Annual mean minimum	23·7	..	..	17·8	..	..	17·8	..	..	22·0	..	..	23·7	..	..
Lowest record	11·7	..	..	6·7	..	..	7·8	..	..	11·1	..	..	13·9	..	..
No. of years	60 (to 1940)	..	..	60 (to 1940)	..	..	60 (to (1940)	..	..	60	..	..	60 (to 1940)	..	..

Rainfall (millimetres)

Southern Tropical Dry Deciduous Forests.

Month	Bihar Hazaribagh 611 m.	Bihar Gaya 111 m.	Orissa Sambalpur 148 m.	M.P. Indore 555 m.	M.P. Jabalpur 393 m.	M.P. Raipur 296 m.	Maharashtra Dohad 333 m.	Maharashtra Nagpur 312 m.	A.P. Aurangabad 306 m.	A.P. Warangal 269 m.	A.P. Cuddapah 130 m.	Mysore Belgaum 780 m.	Mysore Bangalore 921 m.	Madras Salem 278 m.	Madras Tiruchirapalli 78 m.
January	23	18	11	6	21	9	2	9	7	10	10	3	6	7	25
February	32	22	24	4	19	22	1	17	4	15	3	1	7	8	13
March	24	13	22	2	14	18	2	15	5	12	5	10	10	13	9
April	14	6	15	3	8	16	1	15	6	23	15	45	41	49	46
May	50	24	27	13	16	23	17	19	18	31	38	58	106	117	84
June	212	164	256	147	179	230	90	224	138	153	75	206	73	80	41
July	331	336	522	283	492	381	229	371	171	232	103	434	100	96	34
August	336	349	484	207	431	364	176	290	122	177	133	245	127	167	97
September	227	191	230	164	214	195	143	204	170	186	153	122	169	154	120
October	79	48	54	31	48	55	36	55	46	66	123	121	149	164	183
November	40	13	21	16	11	14	17	20	24	28	90	39	68	97	148
December	7	5	4	7	9	5	20	12	7	6	21	9	11	26	71
Total for year (M.A.R.) . .	1,347	1,187	1,670	882	1,462	1,332	715	1,251	719	939	769	1,294	866	980	872
No. of rainy days	75	59	74	47	65	64	40	63	45	54	46	81	57	62	45
No. of months with less than 60 mm.	7	8	7	8	8	7	8	7	8	7	6	6	5	5	6
M. A. humidity	60	56	62	50	55	57	69	51	48	56	58	66	65	62	60
No. of years	60	60	60	?	?	?	10	60	50	40	?	?	?	60	?

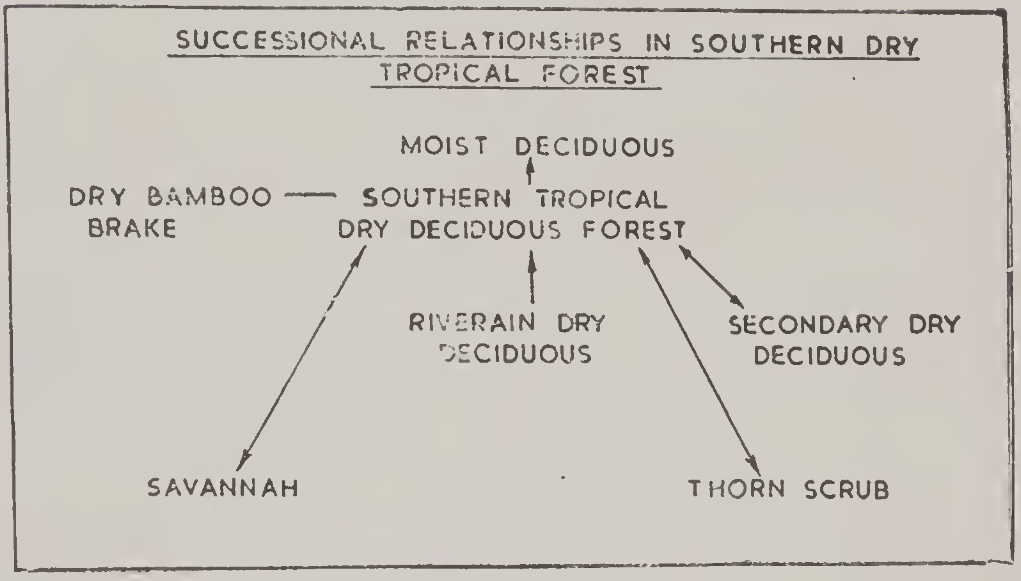
6. SUB-DIVISIONS, SUCCESSION, ETC.

The following climax types are distinguished.

C1—Dry teak-bearing forest

C2—Dry red sanders-bearing forest

C3—Southern dry mixed deciduous forest


SUCCESSIONAL RELATIONSHIPS IN SOUTHERN DRY TROPICAL FOREST
MOIST DECIDUOUS
DRY BAMBOO BRAKE
SOUTHERN TROPICAL DRY DECIDUOUS FOREST
RIVERAIN DRY DECIDUOUS
SECONDARY DRY DECIDUOUS
SAVANNAH
THORN SCRUB

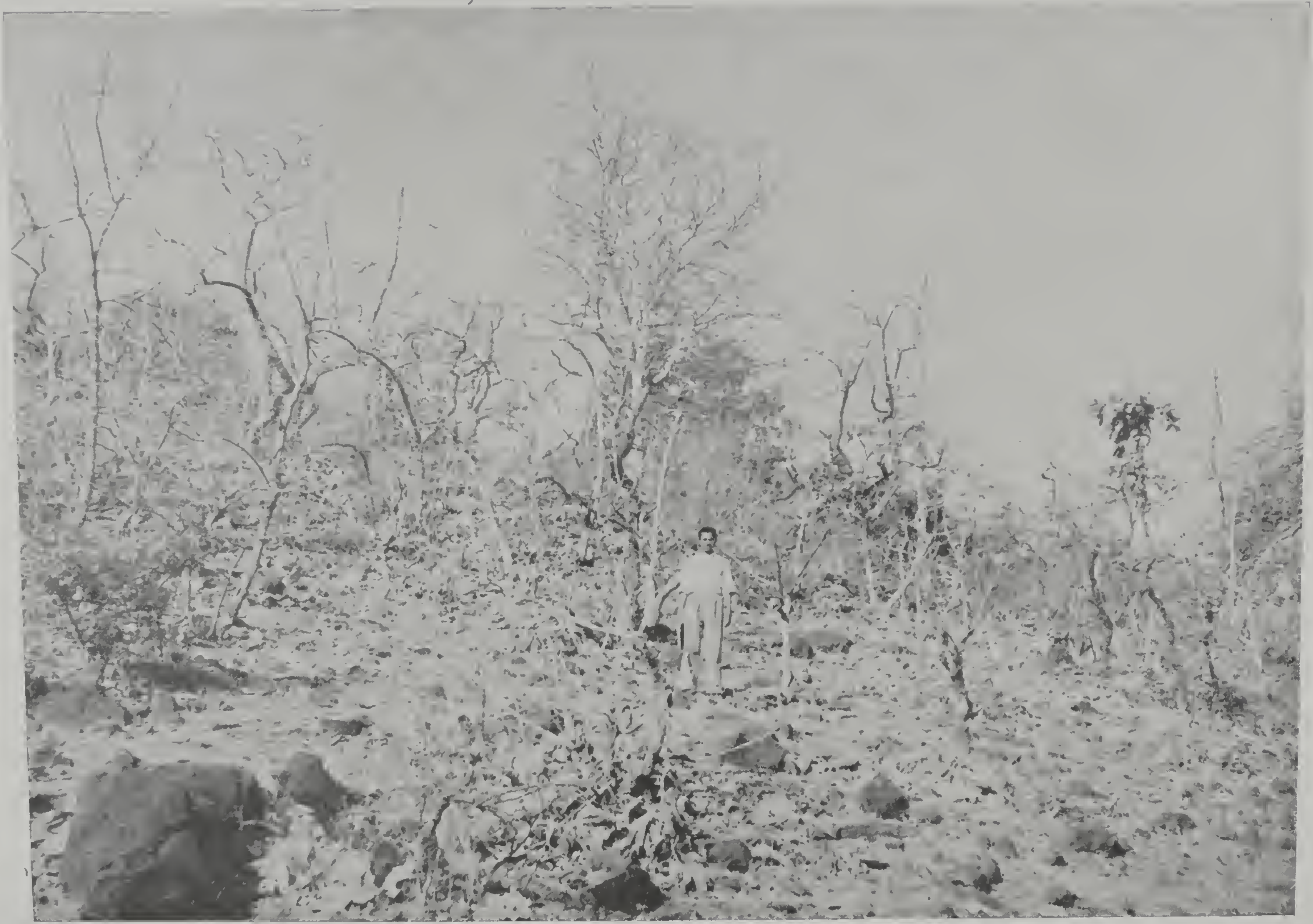
C1. Dry teak-bearing forest

NOMENCLATURE.—Dry teak forest. Dry mixed forest with teak poles.

DESCRIPTION.—As for the sub-group (p. 174) but excluding the poorest parts of it. Unless considerably affected by human activities, the canopy is fairly complete and the trees are sufficiently large, tall and well grown to yield sawn timber. Teak of 3rd and 4th site quality is included here, and the occurrence of teak in any quantity is indicative of the type. The majority of the tree species occurring in this type coppice freely when felled.

DISTRIBUTION.—That of the subgroup. It is met with widely in S. India extending a few degrees north of the tropic.

LOCALITY FACTORS.—Rainfall 1,000 to 1,250 (—1,750) mm. The difference between this and the following type is usually due more to soil conditions than to rainfall and other climatic factors, and the present type occupies the physiologically moister soils with a tendency to be more frequent with higher rainfall. Dry shallow soils on hill-sides are particularly favoured and the change from the moist deciduous forest is often quite sharp as one leaves the moister valleys.



VERY DRY TEAK FOREST

Transitional type showing mixture of *Anogeissus pendula* and teak on exposed sandstone with basalt boulders.

Madhya Pradesh. *M. A. Waheed Khan*

7 FRI&C(6

SUBDIVISION.—The following subtypes are recognised.

C1a.—Very dry teak forest

Rainfall less than 900 mm.; dry infertile soils; teak in low to fair amount mixed with dry deciduous species; ground cover scanty; seedling regeneration practically absent; fires annual; grazing heavy.

C1b.—Dry teak forest

Rainfall 900 to 1,300 mm.; shallow or porous or clayey soils; teak present in high proportion, sometimes practically pure; undergrowth high and patchy; seedlings in groups and patches; fires frequent; grazing heavy.

C1a. Very dry teak forest

Very open forest of very poor quality on stony, detrital, truncated, and shallow soils, usually derived from crystalline rocks or trap.

Characteristic species with the *Tectona* are *Boswellia serrata*, *Anogeissus latifolia*, *Sterculia urens*, *Cochlospermum religiosum*, *Acacia catechu* and occasionally *Anogeissus pendula*, especially in transition zone to *Anogeissus pendula* edaphic community.

ILLUSTRATION.—Plate 38.

FLORISTICS.—

(i) *Chittorgarh Division, Rajasthan.*—

I. *Tectona grandis** (c), *Terminalia tomentosa* (c), *Anogeissus latifolia** (c), *Emblica officinalis* (o), *Cochlospermum religiosum** (o), *Soymida febrifuga* (c), *Diospyros melanoxylon* (f), *Miliusa tomentosa* (o), *Cassia fistula* (o), *Mitragyna parvifolia* (o), *Boswellia serrata* (lc), *Sterculia urens* (r), *Butea monosperma* (la), *Holoptelea integrifolia* (r), *Madhuca indica* (o), *Aegle marmelos* (o), *Dalbergia paniculata* (c).

II. *Acacia catechu** (a), *Gardenia* spp., *Zizyphus xylopyrus*, *Flacourtia indica*.

III. *Carissa carandas*, *Securinega leucopyrus*, *Zizyphus nummularia*, *Woodfordia fruticosa*.

IVa. *Cassia tora*, *Atylosia* spp.

IVb. *Apluda mutica*, *Themeda* spp., *Dichanthium annulatum*.

(ii) *Banswara and Udaipur Divisions, Rajasthan.*—

I/II. *Tectona grandis** (va) 80%, *Terminalia tomentosa* (f), *Diospyros melanoxylon* (c), *Soymida febrifuga* (o), *Miliusa tomentosa* (o), *Schrebera swietenioides* (o), *Mitragyna parvifolia* (r), *Boswellia serrata* (o), *Lannea coromandelica* (c), *Anogeissus latifolia** (c), *Emblica officinalis* (o), *Butea monosperma* (la), *Dalbergia paniculata* (o), *Dolichandrone atrovirens* (r), *Acacia leucophloea* (o), *Aegle marmelos* (o), *Pongamia pinnata* (r), *Tamarindus indica* (r), *Phoenix sylvestris* (lc).

IIa. Patchy. *Dendrocalamus strictus.*

III. Light. *Holarrhena antidysenterica, Helicteres isora, Carissa* spp.

IVa. Light. *Cassia tora, Borreria hispida, Ocimum* sp., *Tridax procumbens, Acanthaceae, Sida* spp., *Moghania* spp.

IVb. *Themeda* spp., *Eragrostis* spp., *Apluda mutica, Mnesithea laevis, Heteropogon contortus, Andropogon pumilus, Aristida* spp.

(iii) *Ajanta, Aurangabad Division, Maharashtra.*—

I. *Tectona grandis** (f), *Boswellia serrata** (f), *Sterculia urens* (lf), *Anogeissus latifolia**(a), *Dalbergia latifolia* (o), *Lannea coromandelica* (f), *Salmalia malabarica* (o), *Azadirachta indica* (o), *Cordia dichotoma* (f).

II. *Terminalia tomentosa* (o), *Acacia catechu** (a), *A. leucophloea* (f), *Hardwickia binata* (lf), *Zizyphus* spp., *Wrightia tinctoria.*

III. *Nyctanthes arbor-tristis* (a), *Lantana camara* (la), *Gymnosporia spinosa* (f), *Euphorbia* sp. (lf).

C1b. Dry teak forest

Mixed dry deciduous forest with teak usually forming the major proportion of the crop on shallow porous or stiff clayey soils. Characteristic species are *Anogeissus latifolia*, *Diospyros tomentosa, Hardwickia binata* and other common dry deciduous trees.

ILLUSTRATIONS.—Plates 39 and 40.

FLORISTICS.—

(i) *Madhya Pradesh* (General floristics).—

I/II. *Tectona grandis** (va), *Anogeissus latifolia** (a), *Diospyros tomentosa** (lf). *Pterocarpus marsupium* (o), *Dalbergia latifolia* (o), *Cassia fistula* (o), *Butea monosperma* (o), *Adina cordifolia* (o), *Mitragyna parvifolia* (o), *Bridelia retusa* (o), *Aegle marmelos* (o), *Lagerstroemia parviflora* (o), *Wrightia tinctoria* (o), *Bauhinia* spp. (o), *Alangium salvifolium* (o).

IIa. *Dendrocalamus strictus* (la).

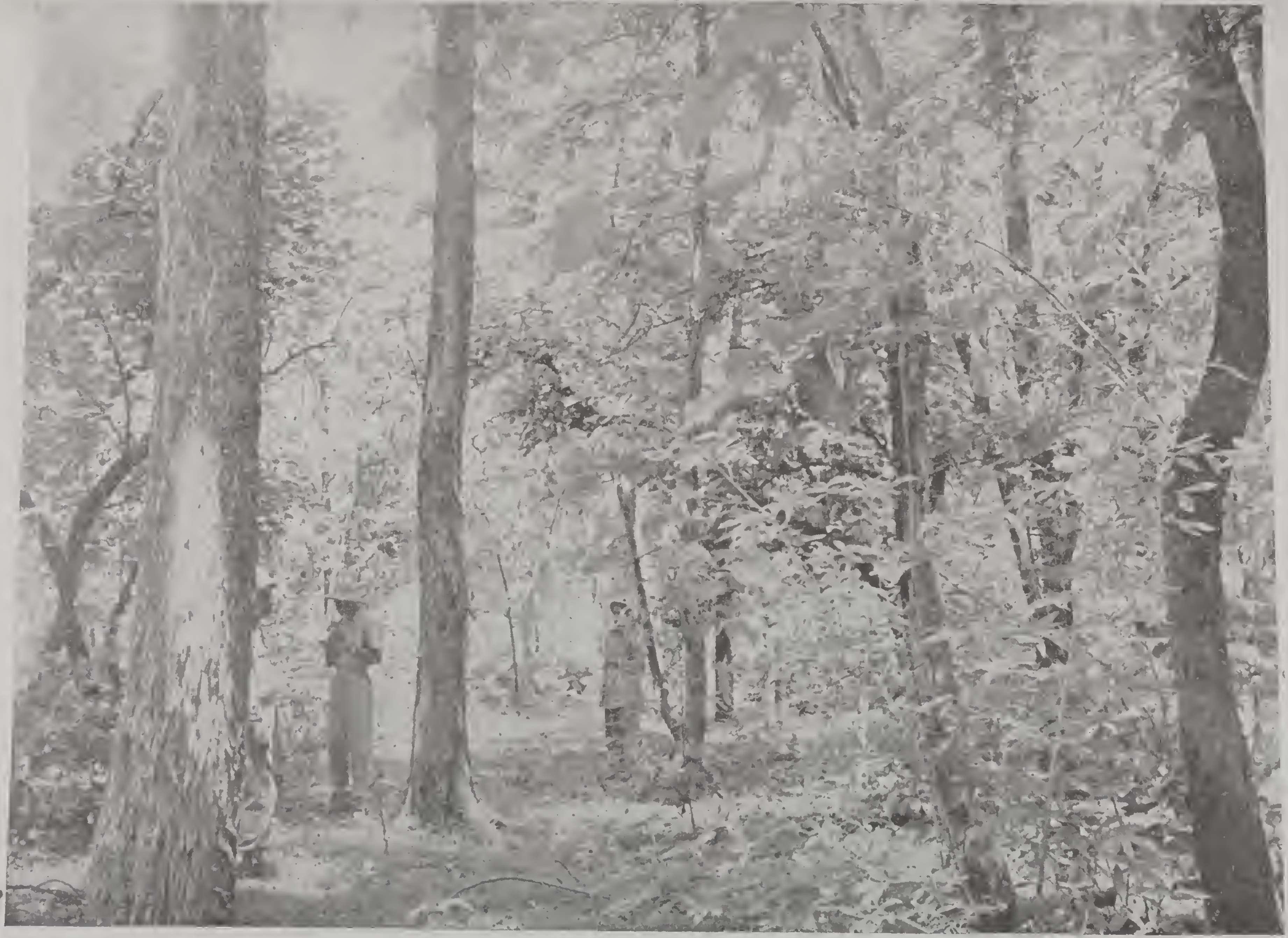
III. *Nyctanthes arbor-tristis* (la), *Woodfordia fruticosa* (r), *Helicteres isora* (f), *Grewia hirsuta* (f), *Gymnosporia spinosa* (o), *Indigofera pulchella* (o), *Adhatoda vasica* (f), *Carissa* spp. (f), *Holarrhena antidysenterica* (f), *Lantana camara* (o).

IVa. *Cassia tora* (f), *Euphorbia* spp. (f), *Xanthium strumarium* (o).

IVb. *Apluda mutica* (f), *Aristida* spp. (f), *Chloris inflata* (f), *Eragrostiella* spp. (f), *Iseilema laxum* (f), *Heteropogon contortus* (f), *Themeda quadrivalvis* (f), *Dichanthium annulatum* (f).

V. *Abrus precatorius* (f), *Acacia caesia* (f), *Acacia pennata* (f), *Combretum decandrum* (o), *Cryptolepis buchanani* (f), *Millettia auriculata* (o), *Tinospora cordifolia* (o), *Ventilago calyculata* (o), *Zizyphus oenoplia* (o).

Par. *Vanda* (r), *Loranthus* (f); *Viscum* (r), *Cuscuta reflexa* (o).



DRY TEAK FOREST

Tectona grandis with *Feronia limonia* and *Butea monosperma* associates and *Alangium salviifolium* understorey.

Preservation Plot, Mand Reserve, Rewa, Madhya Pradesh.

S. K. Seth

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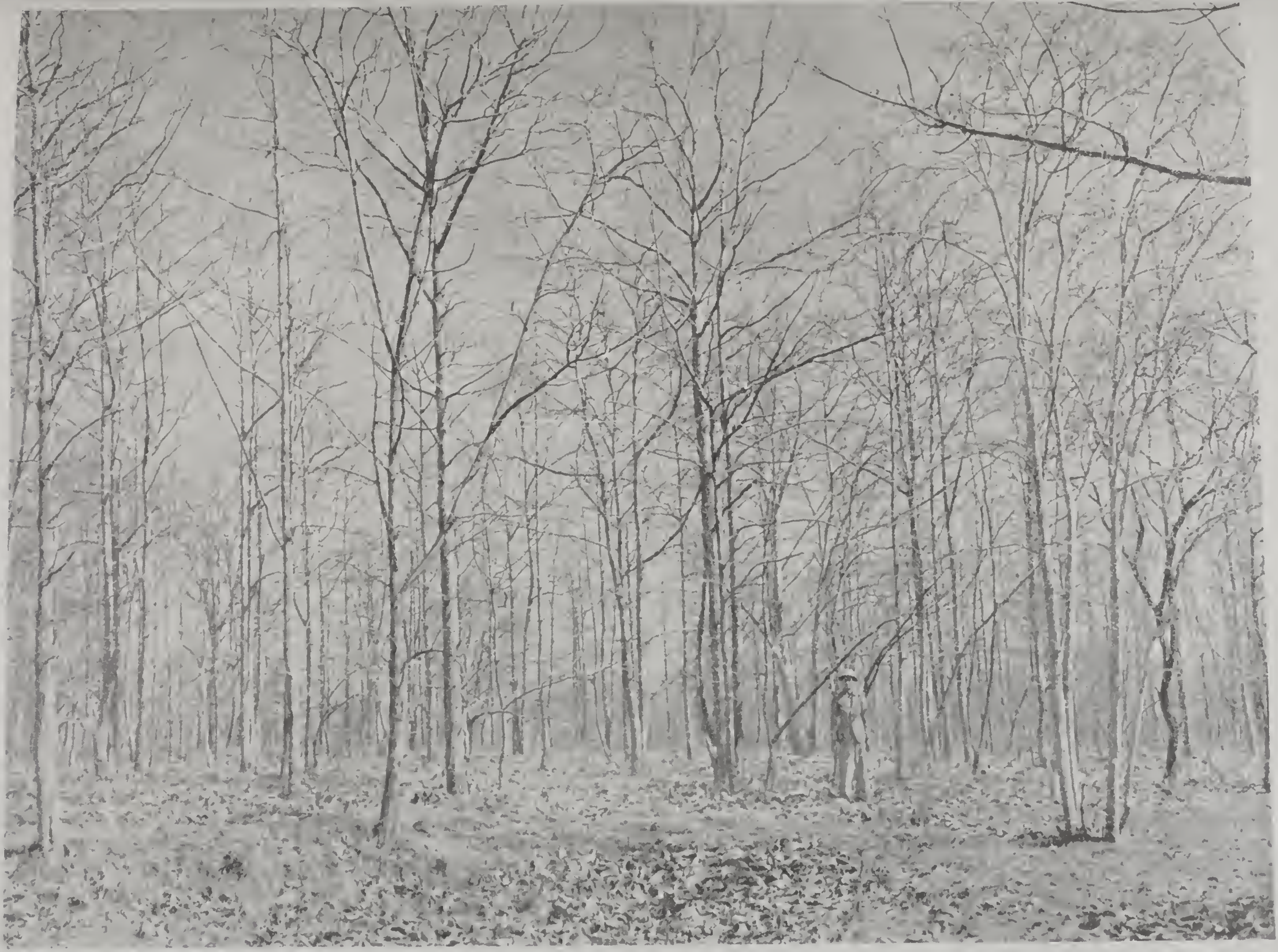


DRY TEAK FOREST

Almost pure teak on murram and black cotton soil overlying trap. Nimar Division, Madhya Pradesh.

M. V. Laurie

(ii) *Indore and Kannod, Madhya Pradesh.*—

I. *Tectona grandis** (va), *Terminalia tomentosa*, *Lannea coromandelica* (f), *Diospyros tomentosa** (f), *Madhuca indica* (f), *Miliusa tomentosa* (f), *Anogeissus latifolia** (f), *Soymida febrifuga* (o), *Mitragyna parvifolia* (o), *Boswellia serrata* (o), *Hardwickia binata** (o), *Dalbergia paniculata*, *Dillenia pentagyna*.

II. *Butea monosperma* (f), *Buchanania lanzan* (o), *Emblica officinalis* (o), *Cassia fistula* (o), *Acacia catechu*, *Bauhinia racemosa* (o), *Holarrhena antidysenterica* (lf), *Flacourtia indica* (o), *Randia dumetorum*.

IIa. *Dendrocalamus strictus* (lf).

III. *Helicteres isora* (f), *Calotropis gigantea* (o), *Grewia* sp. (o), *Woodfordia fruticosa* (lf), *Nyctanthes arbor-tristis* (f).

IVa. *Cassia tora* (f), *Ocimum* sp. (lf), *Xanthium strumarium* (lf).

IVb. *Themeda quadrivalvis*, *Heteropogon contortus*, *Cymbopogon martinii*, *Sehima sulcatum*, *Iseilema*, *Saccharum spontaneum*, *Aristida* sp.

V. *Acacia caesia* (f), *Zizyphus oenoplia* (f), *Tinospora cordifolia* (o), *Abrus precatorius* (r).

(iii) *Tenduchua, N. Raipur Division, Madhya Pradesh.*—

I/II. *Tectona grandis** (20-90%), *Terminalia tomentosa*, *Diospyros tomentosa**, *Anogeissus latifolia**, *Cleistanthus collinus*, *Pterocarpus marsupium*, *Adina cordifolia*. *Ougeinia oojeinensis* (o), *Dalbergia latifolia* (o).

IIa. *Dendrocalamus strictus* (a).

III. *Helicteres isora*, *Strobilanthes* sp., *Woodfordia fruticosa*.

IV. *Themeda triandra*.

V. *Bauhinia vahlii*.

NOTE.—The valley areas provide transitions towards moist deciduous forest but the slopes are typical. Rainfall about 1,500 mm, elevation 300-750 m.

(iv) *Seoni Division, Madhya Pradesh* ("*Medium quality teak forest with bamboos*").—

I/II. *Tectona grandis** (40%), *Terminalia tomentosa*, *Diospyros melanoxylon**, *Anogeissus latifolia**, *Lagerstroemia parviflora*, *Emblica officinalis*, *Lannea coromandelica*, *Ougeinia oojeinensis* (l), *Pterocarpus marsupium* (o), *Dalbergia latifolia* (a).

IIa. *Dendrocalamus strictus* (a) (impenetrable masses).

III. *Indigofera pulchella*, *Moghania* spp.

IV. *Millettia auriculata* (o), Climbers not common.

(v) *Banswara Division, Rajasthan.*—

I. *Tectona grandis** (va), *Boswellia serrata**, *Lannea coromandelica*, *Anogeissus latifolia**, *Diospyros tomentosa**, *Terminalia tomentosa*, *Butea monosperma* (la), *Hymenodictyon excelsum* (r), *Cochlospermum religiosum* (o), *Cassia fistula*, *Bauhinia racemosa*, *Bridelia retusa*, *Ougeinia oojeinensis*, *Dalbergia latifolia* (o), *Schrebera swietenioides*.

II. *Wrightia tinctoria, Flacourtia indica, Zizyphus xylopyrus.*

IIa. *Dendrocalamus strictus.*

III. *Holarrhena antidysenterica, Nyctanthes arbor-tristis, Zizyphus nummularia.*

IVa. *Cassia tora, Ocimum americanum, Achyranthes aspera.*

IVb. *Themeda quadrivalvis, Heteropogon contortus, Eragrostis* spp., *Dichanthium annulatum, Andropogon pumilus, Aristida hystrix.*

(i) *Nirmal Division, Andhra Pradesh.*—

I. *Tectona grandis*, Pterocarpus marsupium, Anogeissus latifolia*, Dalbergia latifolia, Terminalia tomentosa, Chloroxylon swietenia, Lannea coromandelica, Dalbergia paniculata, Salmalia malabarica, Terminalia bellerica, Madhuca indica, Lagerstroemia parviflora, Boswellia serrata,* Sterculia urens.*

II. *Diospyros tomentosa*, Buchanania lanzan, Acacia chundra, Acacia leucophloea, Aegle marmelos, Soymida febrifuga, Wrightia tinctoria, Butea monosperma, Cleistanthus collinus, Zizyphus xylopyrus.*

III. *Randia dumetorum, Cassia auriculata, Nyctanthes arbor-tristis, Helicteres isora, Zizyphus* spp.

(ii) *Dharwar Taluka, Kanara, Mysore.*—

I/II. *Dillenia pentagyna, Kydia calycina, Terminalia* spp., *Lagerstroemia lanceolata, Adina cordifolia, Tectona grandis*, Anogeissus latifolia*, Madhuca indica, Buchanania lanzan, Salmalia, Grewia tiliaefolia, Lannea coromandelica, Pterocarpus marsupium.*

IIa. *Dendrocalamus strictus, Bambusa arundinacea* (l).

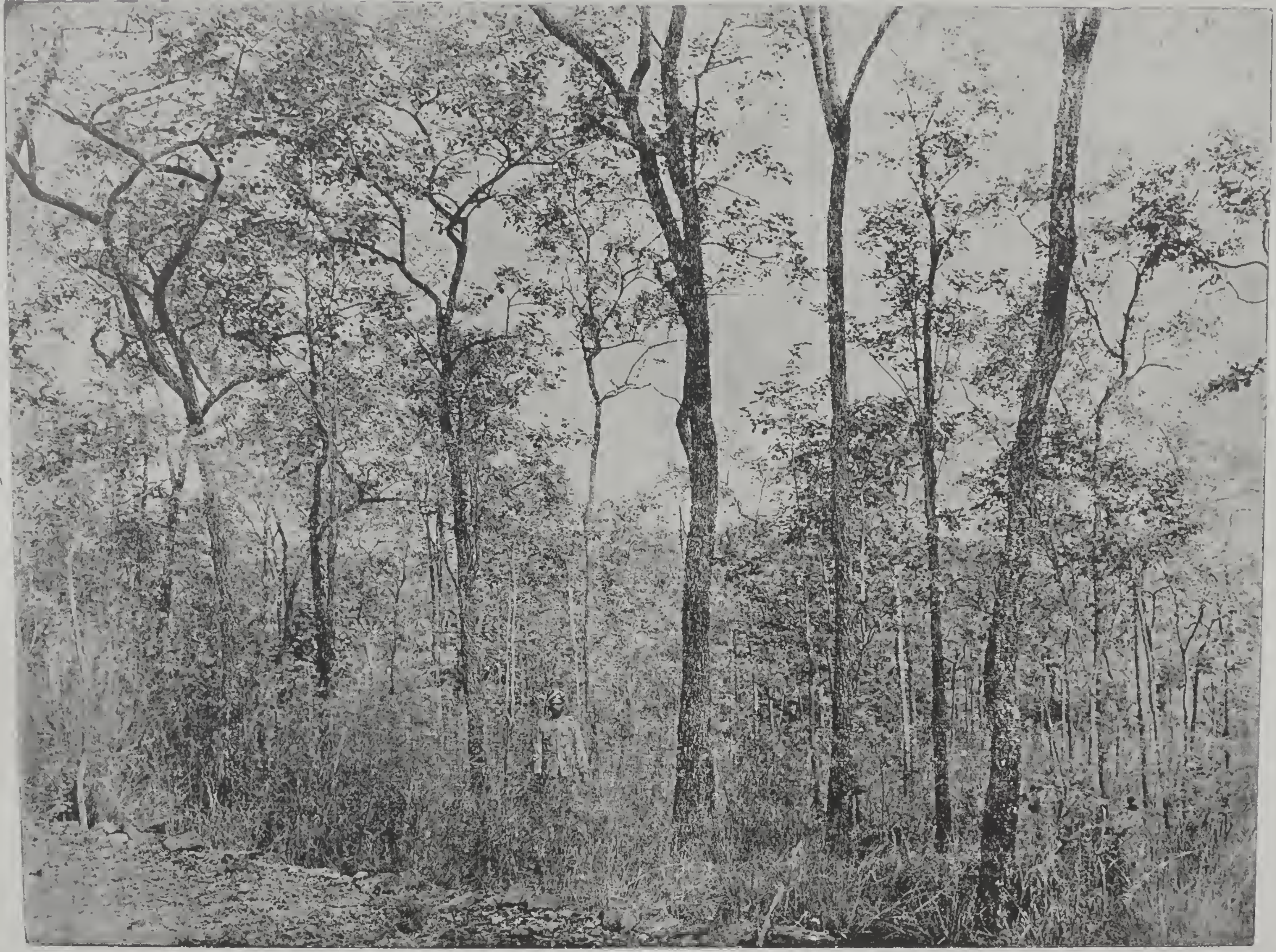
III. *Lantana, Santalum album, Dodonaea viscosa, Carissa opaca.*

(iii) *Madras.* (LEGRIS & VIART)—

I. *Tectona grandis*, Anogeissus latifolia*, Pterocarpus marsupium, Emblica officinalis, Boswellia serrata*, Bridelia retusa*; occasional *Albizzia odoratissima, Terminalia tomentosa, T. bellerica, T. paniculata, Dalbergia paniculata, D. latifolia, Gmelina arborea, Holoptelea integrifolia.*

II. *Chloroxylon swietenia, Diospyros montana, Hardwickia binata*, Premna tomentosa, Cassia fistula, Wrightia tinctoria, Acacia chundra, Atalantia monophylla, Canthium dicoccum, Soymida febrifuga.*

General Note.—The presence or absence of a single species is admittedly a poor basis for differentiation though an aggressive gregarious dominant such as *Shorea robusta* may reasonably be used in this way. The absence of teak in dry forest is often difficult to account for but in many instances intensification of the dryness of the locality physically or physiologically is definitely the cause, and in very general terms, the dry teak forest takes in the moister end of the present formation and the dry miscellaneous the drier end. An interesting overlap of the northern Moist sal and the southern Dry teak (approaching moist teak) is met with in N. Raipur Division, M.P., especially in the Gindola area.



DRY RED SANDERS BEARING FOREST

Nearly pure *Pterocarpus santalinus* with some *Anogeissus latifolia* and *Terminalia chebula.*

There is also a Preservation Plot ("Centenary") at Sitadungri, Satpura Division on sandstone with a mixed sal-teak crop but the sal is dry topped with epicormics.

C2. Red sanders bearing forest

DESCRIPTION.—As described for the subgroup except that *Pterocarpus santalinus* conspicuously predominates sometimes forming pure consociations over extensive areas, and teak is absent. The forests are all periodically burnt and so are rather open and with a heavy growth of grass.

DISTRIBUTION.—Cuddapah, Kurnool, Chittoor and Nellore divisions of Andhra Pradesh.

LOCALITY FACTORS.—On dry hilly often rocky ground usually on quartzite at 150 m. to 760 m. with 750 to 1000 mm. rainfall distributed as shown for Cuddapah (p. 179).

ILLUSTRATION.—Plate 41.

FLORISTICS.—

(i) *S. Cuddapah Division, Andhra Pradesh.* (P.P. 3, 78 hect.) 430 m. on shale with some quartzite, gravelly soil.—

- I. *Pterocarpus santalinus**(open).
- II. Absent.
- III. Thorny shrubs.
- IVb. Grass.

(ii) *S. Cuddapah Division, Andhra Pradesh.*—

- I. *Pterocarpus santalinus**, *Anogeissus latifolia**, *Hardwickia binata*, *Terminalia chebula*, *T. tomentosa*.
- II. *Chloroxylon swietenia**, *Erythroxylon monogynum**, *Randia dumetorum*, *Dolichandrone atrovirens*, *Gardenia latifolia*, *G. gummifera* (dry slopes), *Buchanania lanzan*.
- III. *Grewia* sp., *Croton cabiosus*, *Gmelina asiatica*, *Strobilanthes* sp. (in moist localities).
- IVb. *Heteropogon contortus*, *Cymbopogon* spp.

NOTE.—Apparently a climatic climax, though it disappears on the gneiss of the adjoining Chittoor Division with but little change of climate. The retreating monsoon also brings rain so that the moistest months are July to October inclusive.

C3. Southern dry mixed deciduous forest

DESCRIPTION.—As for the subgroup and differing from the dry teak mainly floristically though some typical species (notably *Boswellia*) are more conspicuous. Thorny plants occur and tend to increase in proportion with the heavy grazing, etc., to which most of the area is subjected. Bamboos are often absent and usually of poor quality when present. Grass is conspicuous till it is grazed down or burnt. Climbers are generally few, but may be heavy locally (*Bauhinia vahlii*, *Acacia* spp.).

DISTRIBUTION.—That of the subgroup, being especially prevalent in the drier localities and sites. It thus occurs throughout Peninsular India.

LOCALITY FACTORS.—Rainfall 875 to 1,125 mm., upto 1,500 mm. on dry sites and soils. Shallow soiled well drained hill sides or undulating ground are typical, and it is often difficult to decide whether the occurrence of the type is due to site or climate. The forests are mostly burnt annually.

ILLUSTRATION.—Plate 42.

GENERAL FLORISTICS.—The most characteristic tree is *Anogeissus latifolia*, whilst *Terminalia tomentosa* is a very typical associate. *Diospyros tomentosa* is also common. *Chloroxylon swietenia*, *Hardwickia binata*, *Boswellia serrata* and *Soymida febrifuga* are very widespread and useful indicators as they are absent from the moist deciduous forests, but their occurrence is rather sporadic and often traceable to soil factors. *Acacia catechu* is often present indicating the relation to thorn forests. The undergrowth is usually thin with a fairly dense growth of grass during monsoon.

(i) *Madhya Pradesh.*—

I/II. *Terminalia tomentosa**(f), *Anogeissus latifolia**(f), *Mitragyna parvifolia* (f), *Schrebera swietenioides* (o), *Madhuca indica* (lf), *Diospyros tomentosa* (la), *Buchanania lanzan* (o), *Lagerstroemia parviflora* (o), *Emblica officinalis* (o), *Cassia fistula* (o), *Aegle marmelos* (o), *Butea monosperma* (o), *Santalum album* (la), *Albizzia* spp. (o), *Boswellia serrata* (o), *Chloroxylon swietenia* (la), *Syzygium cumini* (la), *Hardwickia binata* (la), *Acacia arabica* (r), *Prosopis juliflora* (r), *Sterculia urens* (r).

III. *Nyctanthes arbor-tristis* (la), *Zizyphus* spp. (o), *Helicteres isora* (f), *Vitex negundo* (la), *Adhatoda vasica* (f), *Gymnosporia spinosa* (o), *Randia dumetorum* (o), *Flacourtia indica* (o), *Grewia* spp. (o), *Woodfordia fruticosa* (o), *Balanites aegyptiaca* (o) *Carissa* spp.(o), *Holarrhena antidysenterica* (o), *Lantana camara* (o).

IVa. *Cassia tora* (f), *Achyranthes aspera* (f), *Abutilon* spp. (f), *Corchorus* spp., *Ocimum* spp.(r).

IVb. *Apluda mutica* (f), *Aristida* spp. (f), *Chloris inflata* (f), *Eragrostiella* spp.(f), *Iseilema laxum* (f), *Heteropogon contortus* (f), *Themeda quadrivalvis* (f), *Dichanthium annulatum* (f).

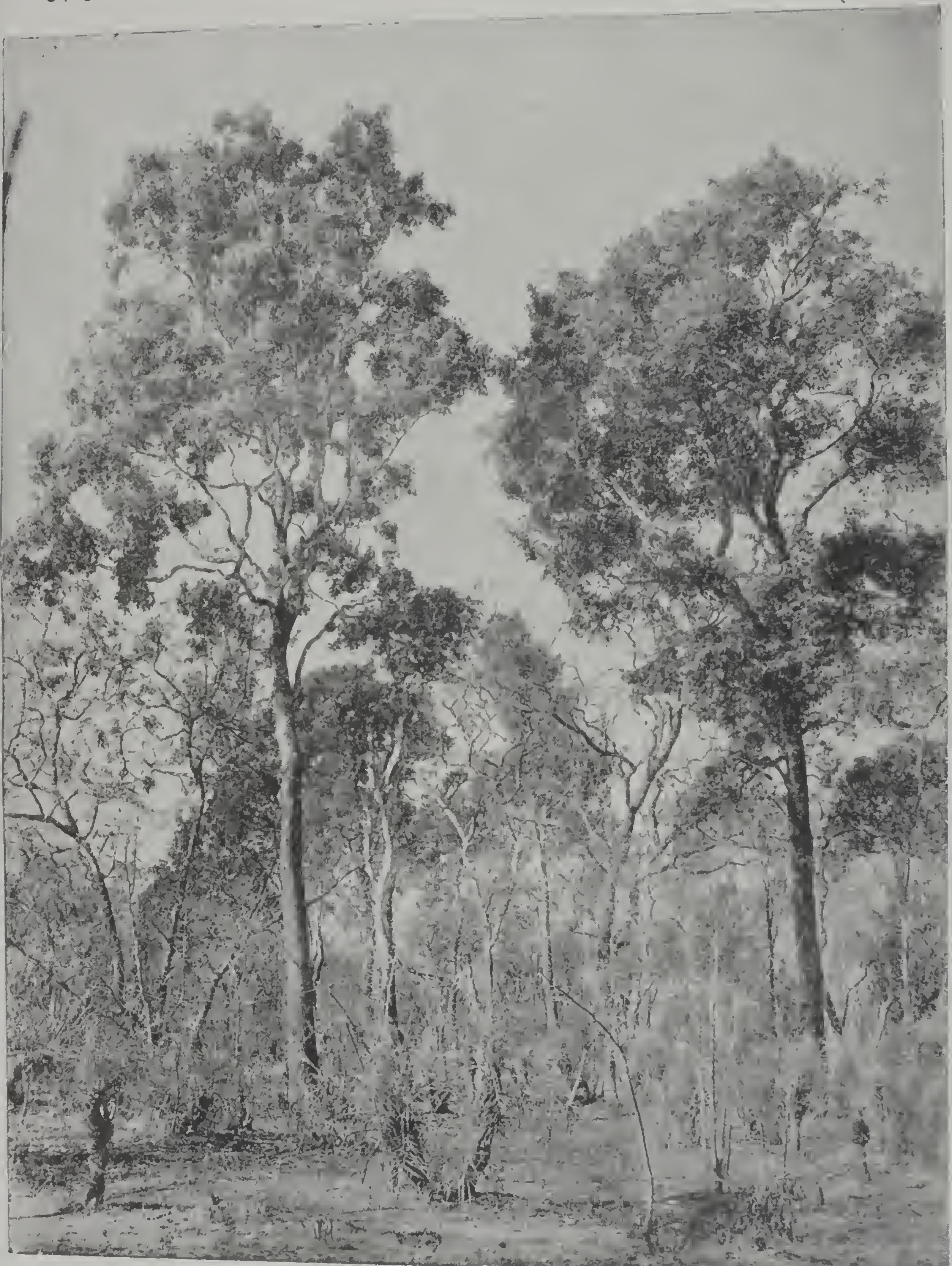
(ii) *Bhandara Division, M. P.*—

I/II. *Terminalia tomentosa**, *Cleistanthus collinus**, *Lagerstroemia parviflora*, *Soymida febrifuga*, *Anogeissus latifolia*, *Chloroxylon swietenia*, *Aegle marmelos*, *Emblica officinalis*, *Acacia catechu*, *Pterocarpus marsupium*, *Zizyphus xylopyrus*, *Ougeinia oojeinensis*, *Lannea coromandelica*.

IIa. *Dendrocalamus strictus* (hilly parts only).

III. *Gardenia resinifera*, *G. turgida*, *Gymnosporia spinosa*, *Ixora arborea*, *Nyctanthes arbor-tristis*, *Woodfordia fruticosa*, *Helicteres isora*, *Indigofera pulchella*.

IVb. *Heteropogon contortus*, *Themeda triandra* etc., *Iseilema laxum* (l).



SOUTHERN DRY MIXED DECIDUOUS FOREST

Shorea talura, Pterocarpus marsupium with *Gardenia gummifera* and *Phoenix* in burnt and grazed forest.

Humchakatta, Tirthihalle, Mysore.

H. G. Champion

V. Climbers few. *Zizyphus oenoplia*, *Acacia pennata*, *Bauhinia vahlii*, *Olax scandens*.

NOTE.—The bamboo is absent over all the flatter areas in which tree growth is poorer from human interference. *Terminalia tomentosa* and *Cleistanthus* predominate in closed canopy on the better sites. *Soymida febrifuga* predominates on poor dry calcareous and quartzite soils especially as second growth.

(iii) *Dhinodar hill, Kutch, Gujarat.*—

I/II. *Sterculia urens**, *Lannea coromandelica*, *Salmalia malabarica*, *Moringa oleifera*.

III. *Euphorbia tirucalli*, *Capparis decidua*, *Lawsonia inermis*.

IVb. *Apluda mutica*.

V. *Tinospora*, *Tragia*.

(iv) *Bhamburda, near Poona, Maharashtra.* (BURNS).—

I/II. *Boswellia serrata**, *Acacia leucophloea*, *Bauhinia tomentosa*, *Rhus mysorensis*, *Lannea coromandelica*, *Flacourtia indica*, *Cochlospermum religiosum*, *Anogeissus latifolia**, *Terminalia tomentosa**, *Gymnosporia spinosa*, *Zizyphus mauratiana*, *Z. oenoplia*, *Z. xylopyrus*, *Azadirachta indica*, *Santalum album*, *Osyris wightiana*, *Tectona grandis*, *Heterophragma quadriculare*, *Stereospermum personatum*, *Dolichandrone falcata*.

IVb. *Dichanthium annulatum*, *Chrysopogon fulvus*, *Panicum isachne*, *Iseilema anthephoroides*, *Heteropogon contortus*, *Aristida* sp., *Sehima nervosum*.

(ILLUSTRATION.—BURNS, *Ind. For.*, 1931; Pl. 31.)

NOTE.—Open grazing area at 600 m with 650 mm. rainfall, on traprock with black soil. Trees scattered in open formation. GARLAND considers this area as a "regressive subsere of mixed deciduous forest" which has much in common with thorn forest.

(v) *Mount Abu, Rajasthan* (middle slopes).—

I/II. *Anogeissus latifolia**, *Erythrina suberosa*, *Boswellia serrata**, *Lannea coromandelica*, *Sterculia urens**, *Terminalia bellerica*.

IIa. *Dendrocalamus strictus*.

NOTE.—On the lower slopes consociations of *Anogeissus pendula* (pure), *Boswellia* and locally pure consociations of *Butea monosperma* dominate. Even on the top at elevation of 1500 m. a bioedaphic climax of dry deciduous type, of which *Anogeissus-Euphorbia Phoenix sylvestris* association is characteristic, dominates on the bare metamorphic rocks. Ultimately on the barest situations only *Euphorbia* occurs.

(vi) *Chirodi R. F., Andhra Pradesh.*—

I. *Terminalia tomentosa** (o), *Bauhinia racemosa* (f), *Acacia arabica* (o), *A. catechu* (f), *Boswellia serrata** (f), *Buchanania lanzan* (o), *Azadirachta indica* (o), *Ougeinia oojeinensis* (r), *Flacourtia indica* (r), (6-8 m. high).

II. *Gymnosporia spinosa* (a), *Zizyphus mauratiana* (a), *Z. xylopyrus* (f), *Morinda tinctoria* (r).

III. *Mimosa hamata* (a), *Terminalia tomentosa* (whippy seedlings 3 m. high) (f), *Grewia hirsuta* (f), (1 m. high).

IVb. *Heteropogon contortus* and other low grasses.

Note.—Formerly heavily grazed.

(vii) *Cuddalore Nallamalais, S. Kurnool Division, A.P.*—

I/II. *Anogeissus latifolia** (40-80 per cent), *Cleistanthus collinus*, *Terminalia tomentosa*, *Pterocarpus marsupium*, *P. santalinus* (lo), *Hardwickia binata* (lo), *Tectona grandis* (lo).

IIa. *Dendrocalamus strictus.*

IIIa. Heavy grass growth.

(viii) *S. Cuddapah Division, A. P.*—

I/II. *Terminalia pallida*, *Shorea talura**, *S. tumbuggaia*, *Eugenia alternifolia*, *Mangifera indica*, *Albizzia odoratissima.*

III. *Phoenix acaulis.*

IVb. Heavy grass (annually burnt).

Note.—This type forms a transition to, or may belong to the moist deciduous forests, occurring on higher slopes and plateaux over 600 m.

(ix) *Dharwar Division, Mysore.*—

I/II. *Acacia catechu*, *Anogeissus latifolia**, *Terminalia tomentosa*, *Soymida febrifuga*, *Chloroxylon swietenia*, *Albizzia amara*, *Cassia fistula*, *Melia azedarach*, *Hardwickia binata*, *Tectona grandis* (lo), *Santalum album.*

III. *Lantana.*

IVb. Fairly good growth of grass.

(x) *Anthargange Sample Plot, Bhadravati Division, Mysore.*—

I. *Anogeissus latifolia** (*a*), *Terminalia chebula* (*o*), *Lagerstroemia parviflora* (*o*), *Terminalia tomentosa** (*f*), *T. paniculata* (*f*), *T. bellerica* (*f*). *Madhuca indica* (*f*), *Grewia tiliaefolia* (o), *Tectona* (o), *Dalbergia latifolia* (o), *Mitragyna parvifolia* (o), *Stereospermum personatum* (o), *Albizzia odoratissima* (o), *A. amara* (o), *Pterocarpus marsupium* (o), *Schleichera* (o), *Strychnos potatorum* (o), *Lannea* (o), *Diospyros montana* (r), *Schrebera* (r), *Soymida* (lf), *Dalbergia paniculata* (o), *Hymenodictyon** (o), *Adina* (o), *Sterculia urens** (d), *Gmelina* (o).

General Note.—In examples (vii), (ix) and (x)—the patches in which teak is a prominent component of the crop could also be considered to belong to Dry teak, 5A/C1.

II. *Zizyphus xylopyrus* (a), *Randia dumetorum* (f), *Bauhinia racemosa* (o), *Ehretia laevis* (*f*), *Emblica officinalis* (f), *Gardenia latifolia* (f), *Flacourtia indica* (f), *Santalum* (o), *Diospyros melanoxylon* (o), *Butea monosperma* (o), *Chloroxylon* (*o*).

IIa. *Dendrocalamus strictus* (la).

III. *Holarrhena* (*a*), *Gardenia turgida* (o), *Randia uliginosa* (o), *Ixora arborea* (r), *Gardenia gummifera.*

IVb. A complete cover of short grass including *Aristida.*

V. *Zizyphus oenoplia* (f), *Acacia intsia* (f), *Celastrus paniculata* (c).

Note.—On hill slopes *Anogeissus latifolia* often strongly predominates forming nearly pure associations.

(xi) *C. Salem Division, Madras.*—

I/II. *Shorea talura**, *Dalbergia latifolia, Terminalia tomentosa, T. chebula, T. paniculata, Pterocarpus marsupium, Albizzia odoratissima, Anogeissus latifolia, Cassia fistula, Hardwickia binata, Santalum album.*

IIa. *Dendrocalamus strictus.*

IVb. Good deal of grass.

Note.—This form occurs at higher elevations, thorn scrub predominating lower down.

(xii) *Anantapur Division, Madras.* (Miscellaneous pole forest).—

I/II. *Hardwickia binata, Anogeissus latifolia*, Chloroxylon swietenia, Erythroxylon monogynum, Acacia chundra.*

Sub-group 5B. Northern Tropical Dry Deciduous Forests

1. NOMENCLATURE

Types under the following names are included:

Punjab	Riverain *shisham* forests. Scrub forests. (Working Plans).
Uttar Pradesh	Dry sal forests. Dry mixed deciduous forests (Bundelkhand, KANJILAL). Dry deciduous forest. Upper monsoon forest (DUDGEON and KENOYER). Miscellaneous low hill deciduous forest (OSMASTON). *Bel* forests (Bahraich and Gonda). *Anogeissus* forest. (OSMASTON). *Shorea-Anogeissus-Pinus* association (part) (OSMASTON). *Bauhinia* formation. (KENOYER). Deciduous riverain forests (OSMASTON). *Khair-Sissu* forests. (Working Plans).

Bihar and Orissa	Dry sal forests. Dry mixed forests (HAINES).
Bengal	Dry mixed forests (small parts).

2. GENERAL DESCRIPTION

The general appearance of the northern tropical dry deciduous forest is very closely similar to that of its southern counterpart, differing most noticeably in the presence of certain conspicuous northern floristic constituents and the absence of some of the characteristic southern species, and in the typically rather different physiography and soils which also affect the composition and structure to some extent. The upper canopy is light but probably fairly even and continuous in the climax form; the latter is, however, very rarely encountered and an irregular often broken canopy is usual in consequence, the trees having relatively short boles and poor form, and a height rarely over 15 m. and often much less. This canopy is formed entirely of deciduous trees most of which extend to the moist deciduous forests with far better development.

There is a considerable intermixture of rather smaller trees which in this type form part of the main canopy though in the moist deciduous they may be in the second storey. There is usually a thin shrubby undergrowth including some evergreen xerophytic species. A feature of the forest is the contrast between the hot weather condition when it is entirely leafless and the soil fully exposed, and the monsoon condition when it takes on an almost luxuriant appearance from the growth of an ephemeral herbaceous vegetation coupled with the leafing out of the trees and shrubs. Only one species of bamboo occurs but is an important feature in some sub-types; it also is leafless during the hot weather. Grass is always present and is nearly always burnt off annually; it does not include any of the large forms.

3. DISTRIBUTION

Throughout northern India except in the eastern parts which are too moist (apart from restricted localities with exceptionally intensive drainage) and in the most western parts which are too dry. Uttar Pradesh, Bihar, Orissa and Punjab include the most extensive occurrences, whilst Madhya Pradesh and Bundelkhand (U. P.) provide transitions between the northern and southern variations. As an edaphic climax, it is met with in areas of varying extent through much of the moist deciduous type affecting such sites as south facing hill sides, flat hill tops, eroded ground and high intensively drained gravel terraces. It extends with but little change up the lower slopes of the Himalaya, particularly on the outer ranges, to about 1,250 m. and sometimes even higher, rapid drainage and strong insolation discounting the effects of the often relatively high rainfall.

4. LOCALITY FACTORS

Temperature.—The temperature variations for a selection of fairly representative localities for which data are available are tabulated on the next page. Jhansi marks the transition to the southern form.

The mean annual temperature is normally 24° to 27°C dropping rather lower at the northern limit (*e.g.* Ludhiana). The high summer temperatures are a characteristic feature (highest temperatures recorded being about 43°C), all stations having a mean minimum of over 17°C and a mean maximum over 30°C indicating a big seasonal range, the daily range being also great. The mean temperature for January averages about 15.0° C and the lowest recorded minimum —2.2° to 6.1° C. The hottest month is June, with a monthly mean over 30°C.

Temperature data (centigrade)
Northern Tropical Dry Deciduous Forests

State, Station Altitude	J. & K. JAMMU 336 m.			Punjab LUDHIANA 248 m.			Uttar Pradesh ROORKEE 274 m.			Uttar Pradesh LUCKNOW 113 m.		
Temperature °C Month	Mean	Mean max.	Mean min.	Mean	Mean max.	Mean min.	Mean	Mean max.	Mean min.	Mean	Mean max.	Mean min.
January .	13·6	18·4	8·8	7·7	19·4	6·5	13·4	20·2	6·5	15·8	23·3	8·4
February .	15·5	20·3	10·7	10·3	21·8	8·6	15·4	22·5	8·3	18·3	25·9	10·8
March . .	20·6	26·1	15·2	15·9	28·4	13·5	20·8	28·8	12·8	24·3	32·7	15·9
April . .	26·4	32·2	20·5	22·9	35·4	19·2	26·9	35·4	18·3	30·1	38·6	21·6
May . .	32·1	37·7	26·4	28·8	40·1	24·3	31·2	39·0	23·3	33·3	40·8	25·7
June . .	33·6	39·2	28·1	30·4	39·8	27·2	31·9	37·9	26·0	32·8	37·9	27·6
July . .	30·8	35·2	26·3	29·1	36·3	26·8	29·5	33·4	25·6	30·0	33·6	26·4
August . .	29·3	33·2	25·4	28·0	34·9	26·2	28·6	32·1	25·1	29·2	32·5	25·9
September .	28·9	33·3	23·9	26·2	34·9	23·3	27·7	32·5	22·8	29·0	33·3	24.7
October .	25·4	31·2	19·6	20·6	33·5	17·3	23·8	31·2	16·3	26·1	33·0	19·2
November .	19·5	25·6	13·4	13·1	27·4	10·6	18·2	26·4	9·8	20·6	28·8	12·3
December .	14·5	20·0	9·5	8·3	21·6	6·8	14·1	21·8	6·3	16·4	24·4	8·5
Annual mean .	24·2	..	..	20·1	..	..	23·4	..	..	25·5	..	..
Annual mean maximum .	29·4	..	..	31·2	..	..	30·1	..	..	32·1	..	..
Highest record .	?	..	..	41·8	..	..	46·7	..	..	28·3	..	..
Annual mean minimum .	19·0	..	..	17·6	..	..	16·8	..	..	18·9	..	..
Lowest record .	?	..	..	—1·7	..	..	—2·2	..	..	1·7	..	..
No. of years (up to 1955).	?	..	..	50	..	..	60 (1940)	..	..	60 (to 1940)	..	..

Temperature data (centigrade)—concld.

State, Station Altitude	Uttar Pradesh JHANSI 251 m.			Uttar Pradesh VARANASI 76 m.			West Bengal MIDNAPUR 45 m.			Rajasthan KOTAH 257 m.		
Temperature °C Month	Mean	Mean max.	Mean min.	Mean	Mean max.	Mean min.	Mean	Mean max.	Mean min.	Mean	Mean max.	Mean min.
January . .	17·2	24·5	9·9	16·2	23·4	8·9	20·1	27·1	13·1	17·8	25·1	10·6
February .	19·8	27·2	12·3	18·8	26·3	11·2	22·9	29·7	16·2	20·4	27·8	13·0
March . .	25·8	3·6	18·0	24·8	33·1	16·4	27·9	35·1	20·8	26·1	33·7	18·4
April . .	31·7	39·2	24·1	30·4	38·8	22·0	31·4	38·3	24·6	31·5	38·7	24·3
May . .	35·6	42·5	28·6	33·5	40·8	26·2	31·8	37·7	25·9	35·6	42·0	29·2
June . .	34·6	40·0	29·2	33·1	38·3	27·8	30·4	34·6	26·2	35·0	40·4	29·5
July . .	29·9	33·7	26·2	30·0	33·4	26·5	29·1	32·1	26·1	30·5	34·4	26·6
August . .	28·5	31·8	25·1	28·9	32·0	25·8	28·8	31·8	25·8	28·7	32·0	25·4
September .	28·8	33·2	24·3	29·0	32·8	25·2	28·8	32·1	25·6	29·1	33·5	24·7
October . .	27·2	33·9	20·3	26·3	32·5	20·0	27·4	31·7	23·0	28·1	34·8	21·3
November .	21·9	29·7	14·2	20·8	28·3	13·3	23·3	29·1	17·4	22·7	30·4	15·1
December .	17·9	25·6	10·3	16·5	24·0	9·0	19·8	26·6	13·1	18·7	26·2	11·2
Annual mean .	26·6	..	..	25·7	..	..	26·8	..	..	27·0	..	..
Annual mean maximum .	32·9	..	..	32·0	..	..	32·2	..	..	33·3	..	..
Highest record .	47·8	..	..	47·2	..	..	47·2	..	..	47·8	..	..
Annual mean minimum .	20·2	..	..	19·3	..	..	21·5	..	..	20·8	..	..
Lowest record .	0·6	..	..	1·7	..	..	6·1	..	..	1·7	..	..
No. of years (upto 1955) .	60 (to 1940)	..	..	60	..	..	50	..	..	40	..	..

Rainfall and Humidity.—The typical rainfall is 900 to 1,150 mm. the greater part falling in the short monsoon period July-September, but in the north-west there is appreciable winter rain though this is not important enough to alter the climate from the predominantly summer monsoon type. As usual, on unfavourable sites, the type is developed with a much higher precipitation, frequently upto 1,500 mm. and sometimes even more. The data are tabulated on the next page for representative localities.

Rainfall (millimetres)

Northern Tropical Dry Deciduous Forests

Months	J. & K. MIRPUR 366 m.	J. & K. JAMMU 366 m.	Punjab LUDHIANA 248 m.	Punjab HOSHIARPUR 335 m.	U.P. ROORKEE 274 m.	U.P. LUCKNOW 113 m.	U.P. JHANSI 251 m.	U.P. VARANASI 76 m.	Bihar PALAMAU 229 m.	Orissa BARGARH 117 m.	West Bengal MIDNAPUR 45 m.	Rajasthan KOTAH 257 m.
	Rainfall mm.	Rainfall mm.	Rainfall mm.	Rainfall mm.	Rainfall mm.	Rainfall mm.	Rainfall mm.	Rainfall mm.	Rainfall mm.	Rainfall mm.	Rainfall mm.	Rainfall mm.
January	50	58	33	37	42	19	14	18	23	10	12	6
February	54	62	30	43	39	18	11	17	32	19	34	5
March	49	52	24	33	20	9	8	9	1	22	36	4
April	28	33	15	17	11	6	4	5	10	14	43	5
May	30	24	13	20	19	20	9	14	15	27	120	12
June	49	71	57	76	114	113	106	111	153	224	259	67
July	199	325	201	246	312	305	300	311	340	428	324	258
August	250	299	152	234	295	292	294	302	343	392	324	245
September	81	84	96	113	162	188	150	185	188	201	216	120
October	11	19	10	12	21	33	25	53	49	46	97	17
November.	6	7	3	5	6	6	7	8	14	10	22	6
December	24	32	15	26	17	8	7	6	6	5	4	5
Total for year (M.A.R.) .	829	1,069	650	871	1,050	1,017	937	1,040	85	1,298	1,491	750
No. of rainy days . .	41	50	36	43	48	49	47	51	62	64	80	37
No. of months less than 60 mm. . . .	8	5	8	8	8	8	8	7	8	8	6	8
M. A. Humidity . . .	?	61	51	?	58	60	46	57	45	74	67	43
No. of years . . .	?	?	?	?	?	?	?	60	?	?	55	40

Soil.—The greater part of the climax type is found on the alluvial soil of the Indo-Gangetic plain and the Tertiary Siwalik formations adjoining it, but there are considerable areas on older rocks both crystalline and sedimentary south of the plains in Bihar, Orissa and parts of the Uttar Pradesh. It is also encountered on the older rocks of the Himalaya where these descend to low enough altitudes.

Physiography.—Mostly on the plains and low hills, being particularly associated with eroded hill sides and alluvial terraces.

5. GENERAL FLORISTICS

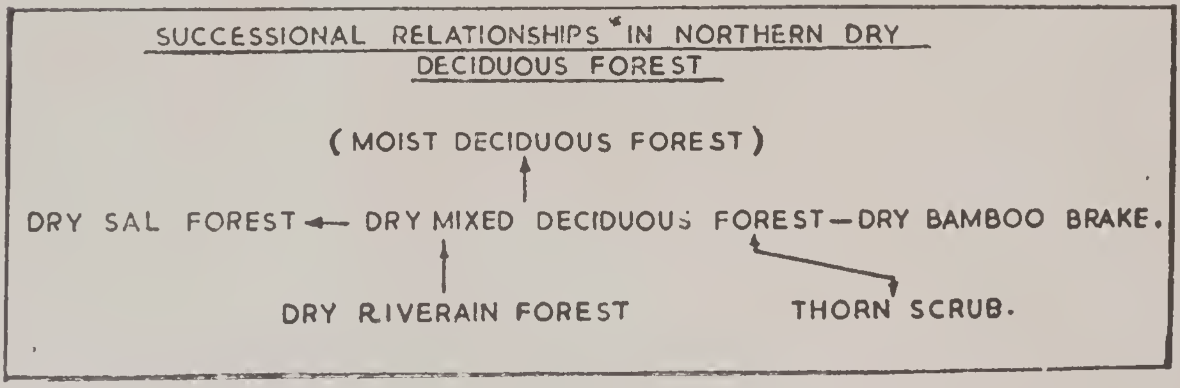
The majority of the tree species which are most abundant and contribute most to the general appearance of the forest also occur in the southern form but several characteristic trees of the latter, such as teak, *Chloroxylon, Soymida, Cleistanthus* are rare or absent, undoubtedly directly or indirectly owing to the colder winter. The trees of the type are also mostly common to the moist deciduous forest with a rather larger element (as also among the undergrowth) from the still drier thorn forest. *Anogeissus latifolia* is very widespread in the type and *Buchanania lanzan, Sterculia, Bauhinia* spp., and poorly grown *Terminalia tomentosa* are the most usual associates. Among shrubs, *Woodfordia* and *Indigofera pulchella* are very generally present and *Carissa opaca* is often very abundant. *Heteropogon contortus* and *Eulaliopsis binata* are the most characteristic grasses.

6. SUBDIVISIONS, SUCCESSIONS, ETC.

The following types are distinguished:

C1 Dry sal-bearing forest

C2 Northern dry mixed deciduous forest



SUCCESSIONAL RELATIONSHIPS IN NORTHERN DRY DECIDUOUS FOREST

C1. Dry sal-bearing forest

DESCRIPTION.—*Shorea robusta* of low quality and height predominates but is more mixed with other species than in the moist deciduous forests and is often broken up into characteristically pure groups or mixed patches of varying extent between which

DRY SIWALIK SAL FOREST

Heavily lopped sal with some chir near the western limit of its range on dry steep hill slopes.

Renuka, Nahan Division, Himachal Pradesh.

S. K. Seth

its associates predominate. The forest is rarely over 18 m. high and the canopy is irregular. Badly shaped boles and hollow stems are prevalent. *Anogeissus latifolia* and *Buchanania lanzan* are the most constant associates. An undergrowth of grass is usual. Bamboo may or may not occur. Regeneration of sal is slow and difficult. The sal is leafless for several weeks in this type.

DISTRIBUTION.—Locally in the Punjab, in Himachal Pradesh and extensively in Uttar Pradesh in the Siwalik hills and on the Gangetic alluvium, and in the hilly tracts of Bihar, Orissa, West Bengal and Madhya Pradesh.

LOCALITY FACTORS.—The climate is more or less indicated by the data given on p. 193 for Hoshiarpur and Palamau. These two stations represent the dry limit for the occurrence of *Shorea robusta* and so for the moister half of the range carrying the northern dry deciduous forests. Rainfall may be as low as 900 mm. with 1,000 mm. more typical, and on poor soils anything up to 1,500 mm. The mean relative humidity for the year is under 60 and for March under 45. The soil may be alluvial or sandy overlying sandstones and conglomerates as in the Siwaliks, or old red soils as on the hills south of the Ganges. Intensive drainage and a long dry season are characteristic.

SUBDIVISIONS.—

Three subtypes are recognized:

C1*a*—*Dry Siwalik sal forest.*

C1*b*—*Dry plains sal forest.*

C1*c*—*Dry peninsular sal forest.*

C1a. Dry Siwalik sal forest

The soil is derived from Siwalik sand rock and conglomerates and is shallow sandy and completely drained. The typical site Quality is III-IV. Regeneration is deficient and very slow and difficult to obtain. Forms transitional to Moist Siwalik sal (3C/C2a) are of frequent occurrence. Bamboos occur locally.

Characteristic associates are :

I. *Anogeissus latifolia.*

II. *Buchanania lanzan.*

III. *Woodfordia fruticosa, Indigofera pulchella.*

IVb. *Eulaliopsis binata.*

ILLUSTRATION.—Plate 43.

FLORISTICS.—

(*i*) *Saharanpur Siwaliks, Uttar Pradesh.*—

I. *Shorea robusta**, *Anogeissus latifolia**, *Buchanania lanzan*, *Terminalia tomentosa*, *Bauhinia variegata*, *Acacia* spp., *Pinus roxburghii*,

II. *Emblica officinalis, Ougeinia oojeinensis, Cassia fistula.*

IIa. *Dendrocalamus strictus.*

III. *Woodfordia fruticosa, Indigofera pulchella, Colebrookia oppositifolia.*

IVb. *Eulaliopsis binata, Heteropogon contortus.*

V. *Bauhinia vahlii.*

(*ii*) *Haldwani Division, Uttar Pradesh.*—

I. *Shorea robusta,* Anogeissus latifolia,* Diospyros tomentosa, Terminalia tomentosa, Schleichera oleosa, Acacia catechu.*

II. *Cassia fistula, Zizyphus xylopyrus.*

IIa. *Dendrocalamus strictus* (*a*).

III. *Nyctanthes arbor-tristis* etc.

IVb. *Eulaliopsis binata, Chrysopogon fulvus, Heteropogon contortus.*

General Note.—Species more usually associated with the moist type may be locally abundant, such as *Lagerstroemia parviflorea, Ehretia laevis, Mallotus philippensis, Miliusa velutina* etc. (For ecological relationships, please see page 197).

C1b. Dry plains sal forest

This subtype is commonly met with on flat ground in the area occupied by moist bhabar sal (3C/C2b) and moist plains sal (3C/C2d) in Uttar Pradesh. The best known examples are in Ramnagar (Jaspur), Haldwani (Malani) and Bahraich (Motipur). In the West, it occurs at the lower end of the *bhabar*, slightly above the *bhabar-tarai* transition and spring levels are usually low. The rainfall is at the lower limit for moist type and maximum temperatures higher. The top soil may be rather clayey, the subsoil also clayey often with dense clay layers almost forming a pan, underlain by gravel or coarse sand. There is superficial water-logging in the rains, the surface drainage also being sluggish.

Recurring waves of mortality are characteristic, reducing the forest to a mixed dry deciduous type. *Terminalia tomentosa, Pterocarpus marsupium, Madhuca indica, Diospyros tomentosa* etc. (in Bahraich) increase in proportion being less susceptible to drought. In Bahraich, the *Aegle* association present on dry yellow clay outcrops has been extending.

Typical Site Quality III: regeneration practically nil. The most characteristic associate is perhaps *Aegle marmelos.*

FLORISTICS.—

(*i*) *Jaspur, Ramnagar Division, Uttar Pradesh.*—

I. *Shorea robusta*, Terminalia tomentosa, T. bellerica, Diospyros tomentosa*, Anogeissus latifolia.*

II. *Miliusa velutina, Buchanania lanzan, Semecarpus anacardium, Acacia catechu, Zizyphus xylopyrus, Z. mauratiana, Mallotus philippensis, Aegle marmelos,*

III. *Clerodendrum viscosum, Glycosmis pentaphylla.*

IVb. *Imperata cylindrica, Eulaliopsis binata.*

(ii) *Motipur, Bahraich Division, Uttar Pradesh*—

I. *Shorea robusta* Adina cordifolia, Lannea coromandelica, Terminalia tomentosa, T. bellerica. Stereospermum suaveolens, Madhuca indica*, Ficus* spp., *Diospyros tomentosa*, Acacia catechu, Aegle marmelos*.*

II. *Feronia limonia, Miliusa velutina, Cassia fistula, Semecarpus anacardium, Ougeinia oojeinensis, Butea monosperma.*

III. *Murraya koenigii, Carissa opaca, Helicteres isora, Moghania chappar, Glycosmis.*

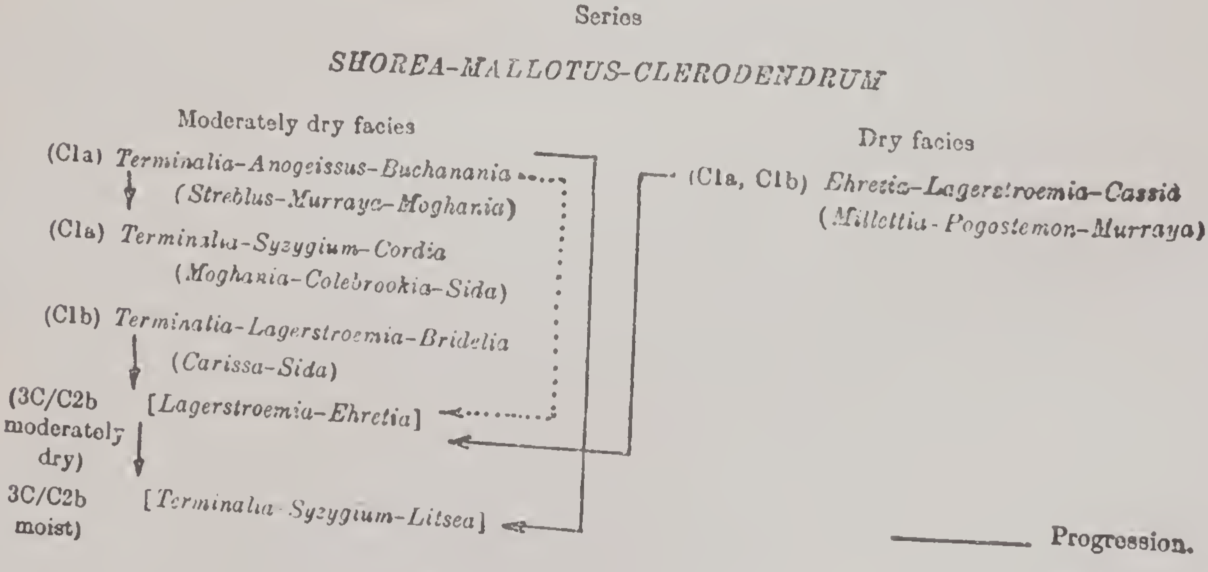
V. *Tiliacora acuminata, Bauhinia vahlii, Acacia pennata, Clerodendrum viscosum.*

ECOLOGICAL RELATIONS.—

BHATNAGAR (1960) has distinguished the following communities in the dry sal forests of Uttar Pradesh. The successional relationships are shown below :

(C1a, C1b) *Shorea-Anogeissus-Colebrookia* (stable preclimax; poor sal regeneration).
Greater moisture ↓
(C1a, C1b) *Shorea-Terminalia-Glycosmis* (dry climax; fine sal regeneration).
Protection ↑ (A1 A2)
(C1b) *Shorea-Ougeinia-Carrisa-Sida* (biotic subclimax, erratic poor sal regeneration).

In a later study SRIVASTAVA (1962) has postulated the following relationships. The typical society of each association is given within brackets.


Series
SHOREA-MALLOTUS-CLERODENDRUM
Moderately dry facies
(C1a) Terminalia-Anogeissus-Buchanania
(Streblus-Murraya-Moghania)
(C1a) Terminalia-Syzygium-Cordia
(Moghania-Colebrookia-Sida)
(C1b) Terminatia-Lagerstroemia-Bridelia
(Carissa-Sida)
(3C/C2b moderately dry)
[Lagerstroemia-Ehretia]
3C/C2b moist)
[Terminalia-Syzygium-Litsea]
Dry facies
(C1a, C1b) Ehretia-Lagerstroemia-Cassia
(Millettia-Pogostemon-Murraya)
Progression.
Degradation.

C1c. Dry peninsular sal forest

This subtype occurs on shallow soils derived usually from crystalline and metamorphic rocks wherever the soil moisture conditions are unfavourable for the development of moist sal, even in areas with a much higher rainfall. The soil often rests directly on hard impervious laterite and is sometimes calcareous. Typical Site Quality III-IV; Sal regeneration fair but slow.

Characteristic associates are:

I. *Anogeissus latifolia*, *Boswellia serrata*.
II & III. *Gardenia* spp., *Wendlandia tinctoria*, *Phoenix acaulis*.
IVb. *Eulaliopsis binata*.

ILLUSTRATION.—CHAMPION, 1933; Plate 1.

FLORISTICS.—

(*i*) *Singhbhum, Bihar.*—

(1) *Shorea-Anogeissus-Woodfordia* association (MOONEY).

I. & II. *Shorea robusta** (a), *Anogeissus latifolia** (a), *Boswellia serrata** (lo) *Cochlospermum religiosum* (o), *Dillenia aurea* (o), *Zizyphus xylopyrus* (f), *Gardenia gummifera* (a).
III. *Woodfordia fruticosa* (f), *Wendlandia tinctoria* (o), *Grewia hirsuta* (o), *Phoenix acaulis* (o).
IVa. *Blumea flava* (o), *Vicoa indica* (o).
IVb. *Arundinella setosa* (a), *Eulaliopsis binata* (lf), *Pseudopogonatherum contortum* (f).
V. No climbers.

(2) *Shorea-Gardenia-Eulaliopsis* association.

I. & II. *Shorea robusta** (a), *Buchanania lanzan* (f), *Eugenia caryophyllifolia* (a), *Gardenia gummifera** (a), *Madhuca indica* (o), *Diospyros tomentosa* (o), *Emblica officinalis* (o).
IIa. *Cephalostachyum pergracile* (lo).
III. *Wendlandia tinctoria* (f), *Phoenix acaulis* (f).
IVa. *Blumea flava*, *Vicoa indica*.
IVb. *Arundinella setosa* (a), *Pseudopogonatherum contortum* (a), *Eulaliopsis binata* (f, lva), *Thysanolaena maxima* (lo), *Pogonathesum paniceum* (lf).

(ii) *Laterite tract, West Bengal.*—

I. & II. *Shorea robusta**, *Madhuca indica*, *Terminalia bellerica*, *T. tomentosa*, *Pterocarpus marsupium*, *Diospyros tomentosa*, *Schleichera oleosa*, *Buchanania lanzan*, *Semecarpus anacardium*, *Salmalia malabarica* (o), *Gmelina arborea* (o), *Terminalia chebula* (o), *Anogeissus latifolia** (o), *Soymida febrifuga* (o).

In hilly areas only—*Boswellia serrata**, *Sterculia urens*, *Acacia catechu*, *Bauhinia* spp., *Dalbergia latifolia*, *Ougeinia oojeinensis*, *Mallotus philippensis*.

IIa. *Dendrocalamus* (lc in hills).

III. Very scanty in plains, mainly,

Cleistanthus collinus, *Holarrhena antidysenterica*, *Nyctanthes arbor-tristis*, *Gardenia gummifera*, *Woodfordia fruticosa*, *Butea monosperma*, *Zizyphus mauratiana*.

IVb. *Heteropogon contortus*, *Chrysopogon aciculatus*, *Saccharum spontaneum*, *Desmostachya bipinnata*, *Aristida setacea*, *Bothriochloa pertusa*, *Eragrostis* spp.

V. *Combretum decandrum*.

(iii) *West Sambalpur*, *Orissa*.—

I. *Shorea robusta**, *Terminalia tomentosa*, *Pterocarpus marsupium*, *Anogeissus latifolia**, *Lagerstroemia parviflora*, *Adina cordifolia*, *Terminalia bellerica*, *Acacia catechu*, *Buchanania lanzan*.

II. *Cleistanthus collinus*, *Chloroxylon swietenia*, *Emblica officinalis*, *Cassia fistula*, *Terminalia chebula*, *Wendlandia tinctoria*, *Symplocos racemosa*.

IIa. *Dendrocalamus strictus*.

III. *Indigofera pulchella*, *Phoenix acaulis* (la).

(iv) *South Raipur Division*, *Madhya Pradesh*.—

I. *Shorea robusta**, *Terminalia tomentosa*, *Pterocarpus marsupium*, *Madhuca indica*, *Anogeissus latifolia**, *Boswellia serrata**.

II. *Buchanania lanzan*, *Diospyros tomentosa*, *Terminalia chebula*, *Emblica officinalis*, *Ougeinia oojeinensis*, *Kydia calycina*, *Bauhinia retusa*, *Cleistanthus collinus*, *Bridelia retusa*.

III. *Woodfordia fruticosa*, *Indigofera pulchella*, *Nyctanthes arbor-tristis*, *Moghania semi-alata*, *Ixora arborea*, *Grewia* spp., *Phoenix acaulis*.

IVb. *Themeda quadrivalvis*, *Thysanolaena maxima*, *Cynodon dactylon*.

V. *Bauhinia vahlii*, *Butea superba*, *Smilax zeylanica*.

GENERAL NOTE—The presence of *Shorea robusta* may perhaps be interpreted as indicating that this subtype stands in the relation of a postclimax association on moister and deeper soils, to the prevailing dry deciduous forests. Conversely the latter might be viewed as an edaphic preclimax on the drier and shallower soils.

(v) *Pachmarhi Plateaux*, *Madhya Pradesh*.—

I. & II. *Shorea robusta**(a), *Chloroxylon swietenia* (la), *Manilkara hexandra* (la), *Terminalia tomentosa* (a), *Boswellia serrata* (o), *Lannea coromandelica* (e), *Lagerstroemia parviflora* (f), *Anogeissus latifolia* (f), *Buchanania lanzan* (f), *Madhuca indica* (o), *Mallotus philippensis* (r).

III. *Sophora mollis* (la), *Rhus trifoliatus* (f), *Dodonaea viscosa* (lf), *Holarrhena antidysenterica* (f), *Phoenix acaulis* (o).

IVa. *Senecio* sp.

IVb. *Heteropogon contortus.*

V. *Clematis* (f), *Bauhinia vahlii* (r).

NOTE.—This appears to be the highest limit for dry sal. The type is undoubtedly edaphically conditioned, occurring on dry sandy pebbly soil derived from Pachmarhi sandstones and conglomerates, in a climate where the natural vegetation should be subtropical wet hill forest.

C2. Northern dry mixed deciduous forest

DESCRIPTION.—The general description for the subgroup applies particularly to this type. Some species form contensive consociations, notably *Anogeissus latifolia*, *Boswellia serrata* and *Cleistanthus collinus*, the latter two being more characteristic of the southern type although *Boswellia* extends upto the Saharanpur Siwaliks. *Anogeissus* often monopolises southern aspects on the hills. *Cochlospermum* is often gregarious on very dry rocky ground.

In most localities the tree canopy has been seriously broken by human activities, so that scattered trees and small groups are now typical. In the climax state, however, it would appear that this upper canopy would be thin but fairly complete, most trees having low spreading crowns. Transitions to the still drier types would be characterised by a broken top canopy. Many tracts are at present occupied almost exclusively by large shrubs and small trees such as *Nyctanthes arbor-tristis*, and it is now difficult to determine just how far their condition is due to maltreatment.

DISTRIBUTION.—Throughout the territory of the sub-group as stated on p. 190.

LOCALITY FACTORS.—Climate and rainfall factors are given on pp. 191-193. The transition between this type and the moist deciduous forest is usually drawn out but it is often sharp on varied terrain where any change of soil or topographical position resulting in drier soil conditions may at once cause a change in type. Similarly towards the N.W., the change to thorn forest involves extensive transitional forms much influenced by biotic factors.

ILLUSTRATIONS.—Plates 44 and 45.

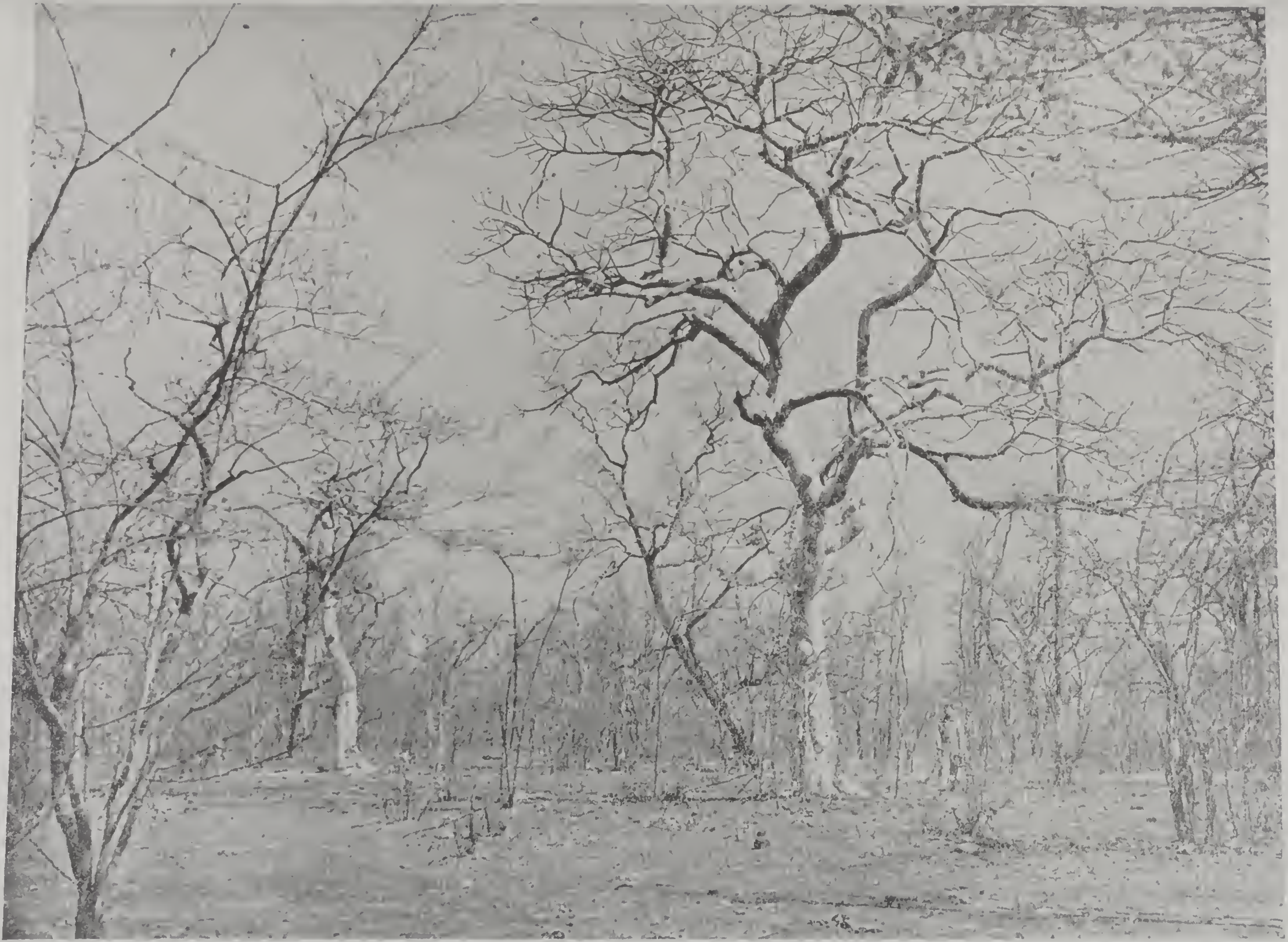
FLORISTICS.—

(i) *Kangra Division, Punjab.*—

I. *Acacia catechu,* Anogeissus latifolia,* Lannea coromandelica, Aegle marmelos, Feronia limonia, Ehretia laevis, Kydia calycina, Ougeinia oojeinensis, Mitragyna parvifolia, Flacourtia indica.*

II. *Mallotus philippensis, Nyctanthes arbor-tristis.*

IIa. *Dendrocalamus strictus**.



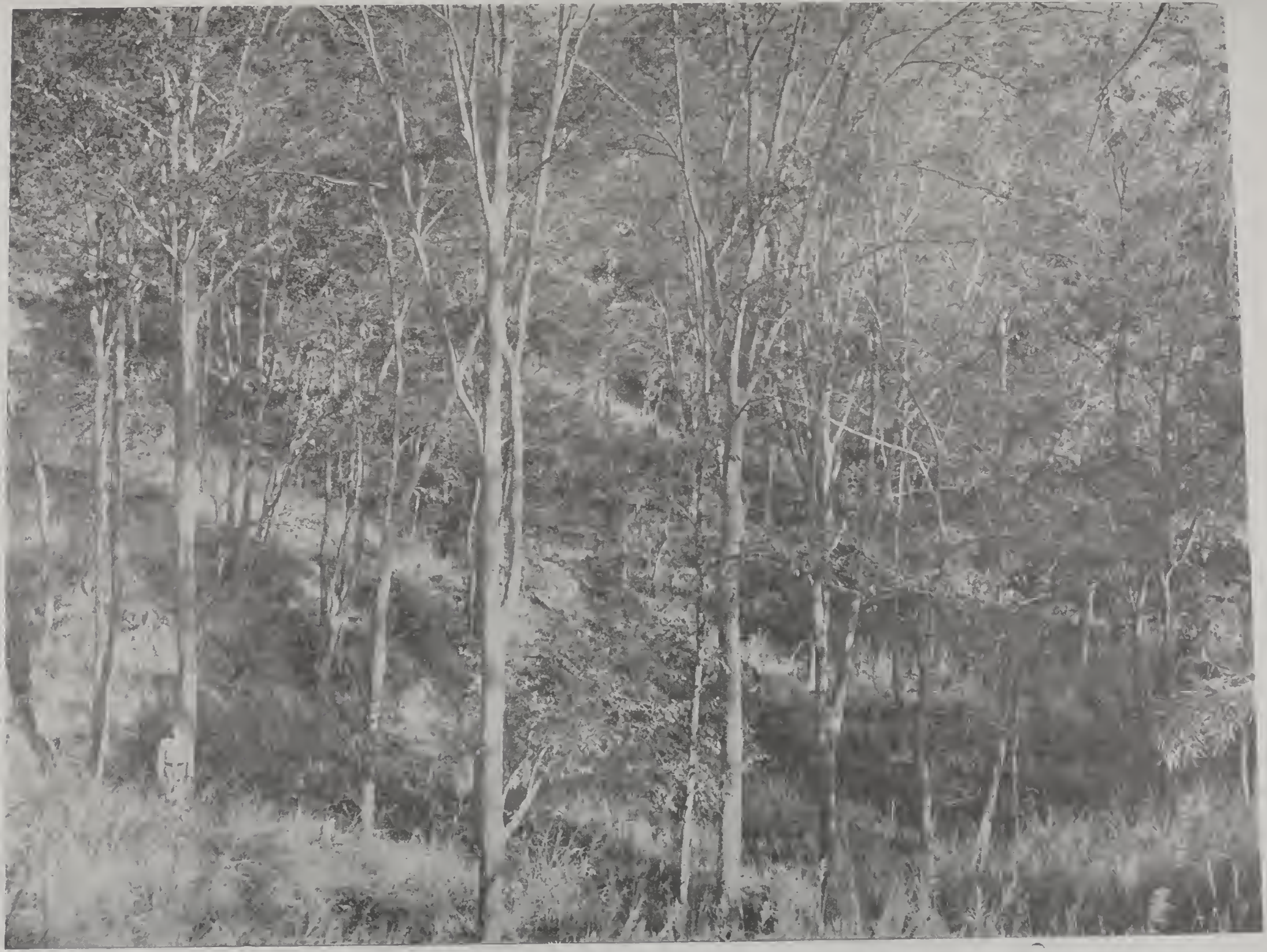
NORTHERN DRY MIXED DECIDUOUS FOREST

Scattered *Sterculia urens* in a mixture of *Anogeissus latifolia*, *Terminalia tomentosa*, *Chloroxylon swietenia* with *Zizyphus xylophyrus*, *Z. oenoplia* and occasional *Flacourtia ramontchi* undergrowth.

Tendukera, Damoh Division, Madhya Pradesh.

M. V. Laurie

7 FRI&C/64



NORTHERN DRY MIXED DECIDUOUS FOREST

Nearly pure *Anogeissus latifolia* over short grass with some *Dendrocalamus strictus*, S. W. aspect, on sand stone.
Bijrani, Ramnagar Division, Uttar Pradesh.

A. E. Osmaston

III. *Carissa opaca,* Dodonaea viscosa,* Woodfordia fruticosa, Adhatoda vasica.*

IV. *Pueraria tuberosa, Bauhinia vahlii, Acacia caesia.* (1932 WORKING PLAN).

(ILLUSTRATIONS—cf. GLOVER, *Ind. For.*, 1934, Pls. 28-30, Hoshiarpur Siwaliks.)

(ii) *Saharanpur Siwaliks, Uttar Pradesh* (Preservation Plot No. 18)—

I. *Anogeissus latifolia* (49%), *Boswellia serrata** (16%), *Acacia catechu* (8%), *Shorea robusta* (4%), *Bauhinia* spp. (5%), *Cochlospermum religiosum* (2%), *Terminalia tomentosa* (1%), *Buchanania lanzan* (1%), *Diospyros tomentosa, Terminalia bellerica, Hymenodictyon excelsum, Garuga pinnata, Kydia calycina, Sterculia palleus, Mitragyna parvifolia, Bridelia retusa.*

II. *Nyctanthes arbor-tristis* (3%), *Gardenia turgida* (2%), *Ougeinia oojeinensis* (2%), *Ehretia laevis* (1%), *Aegle marmelos* (1%), *Emblica officinalis, Feronia limonia, Holarrhena antidysenterica, Cordia dichotoma, Zizyphus xylopyrus, Wendlandia exserta, Cassia fistula, Casearia tomentosa, Butea monosperma, Flacourtia indica, Zizyphus mauratiana.*

IIa. *Dendrocalamus strictus.*

III. *Woodfordia fruticosa, Nyctanthes arbor-tristis, Indigofera pulchella.*

IVb. *Eulaliopsis binata, Heteropogon contortus.*

V. *Bauhinia vahlii.*

Percentages refer to all trees over 20 cm. d.b.h.

NOTE.—This form occurs on the Siwalik hills when erosion is extremely active. The type merges with Siwalik chir pine p. 270.

(iii) *"Plains forest," Saharanpur Division, Uttar Pradesh.*—

I. *Stereospermum suaveolens, Salmalia malabarica, Erythrina suberosa, Lannea coromandelica, Garuga pinnata, Kydia calycina, Hymenodictyon excelsum, Bridelia retusa, Terminalia tomentosa*, Terminalia bellerica.*

II. *Holarrhena antidysenterica, Casearia tomentosa, Ehretia laevis, Miliusa velutina, Mallotus philippensis.*

III. *Adhatoda vasica, Helicteres isora.*

NOTE.—This form occurs on the plains below (ii). It is much grazed.

(iv) *Lalitpur, Jhansi Division, Uttar Pradesh.*—

I. & II. *Lannea coromandelica,* Boswellia serrata,* Terminalia tomentosa,* Diospyros melanoxylon, Anogeissus latifolia,* Elaeodendron roxburghii, Buchanania lanzan, Acacia catechu, Bauhinia racemosa, Aegle marmelos, Butea monosperma, Flacourtia indica, Zizyphus xylopyrus.*

IIa. *Dendrocalamus strictus.*

III. *Nyctanthes arbor-tristis*, Securinega vinea. Zizyphus mauratiana, Helicteres isora, Carissa opaca.*

IV b

IIIa. *Heteropogon contortus, Schima nervosum, Themeda quadrivalvis, Iseilema laxum.*

NOTE.—Typical form of the Vindhyan highlands.

(v) *Western Ganges Khola (high bank), Uttar Pradesh.*—

I. *Holoptelea integrifolia,* Salmalia malabarica, Dalbergia sissoo.*

II. *Cordia dichotoma, Diospyros cordifolia*, Casearia tomentosa, Ehretia laevis, Streblus asper, Premna latifolia, Grewia hainesiana, Nyctanthes arbor-tristis, Zizyphus mauratiana.*

III. *Woodfordia fruticosa, Helicteres isora, Carissa opaca, Indigofera, Vitex negundo, Adhatoda vasica, Murraya koenigii, Calotropis procera, Capparis decidua, Zizyphus mauratiana, Grewia sclerophylla, Mimosa himalayana.*

IVb. *Erianthus munja,* Apluda mutica, Bothriochloa pertusa, Desmostachya bipinnata, Heteropogon contortus, Themeda quadrivalvis, Cenchrus ciliaris, Aristida* spp., *Iseilema laxum, Dichanthium annulatum.*

V. *Zizyphus oenoplia.*

(vi) *Singhbhum, Bihar* (*Cochlospermum-Euphorbia* association, MOONEY).—

I. & II. *Lannea coromandelica* (a) *Gardenia latifolia** (a) *Cochlospermum religiosum** (f), *Sterculia urens** (f), *Chloroxylon swietenia* (lf), *Buchanania lanzan* (f), *Aegle marmelos** (la), *Anogeissus latifolia* (f), *Morinda tinctoria** (lf), *Canthium dicoccum* (lf), *Emblica officinalis* (f), *Euphorbia nivalia** (f), *Protium serratum, Lagerstroemia parviflora, Erythrina suberosa, Stereospermum suaveolens, Ficus* spp.

III. *Woodfordia fruticosa* (f), *Nyctanthes arbor-tristis* (a), *Petalidium barlerioides* (a), *Murraya paniculata* (lf).

IVa. *Sarcostemma acidum*, Eranthemum purpurascens, Justicia* spp. (f), *Rungia, Dicliptera.*

IVb. *Arundinella setosa** (f), *Chrysopogon lancearius** (f), *Cymbopogon martinii** (f), *Themeda triandra* (o).

V. Scanty—*Butea superba, Olax scandens, Jasminum, Erycibe.*

NOTE.—An extremely dry formation found on steep stony southern slopes or rocky hill tops from Rajasthan eastwards and southwards.

(vii) *Singhbhum, Bihar* (*Anogeissus-Mitragyna-Dendrocalamus-Daedelacanthus* association, MOONEY).—

I. & II. *Anogeissus latifolia** (va), *Adina cordifolia** (a), *Mitragyna parvifolia** (a), *Hymenodictyon excelsum**(f), *Aegle marmelos* (f), *Chloroxylon swietenia* (lf), *Schleichera oleosa* (f), *Lannea coromandelica** (f), *Schrebera swietenioides* (f), *Lagerstroemia parviflora* (lf), *Bridelia retusa** (f), and occasional *Shorea, Cochlospermum, Sterculia, Boswellia, Buchanania, Ougeinia, Erythrina, Bauhinia malabarica*, Madhuca, Diospyros montana*, Stereospermum, Vitex peduncularis.*

IIa. *Dendrocalamus strictus** (la).

III. *Petalidium barlerioides** (a), *Helicteres isora* (la), *Strobilanthes auriculatus* (f), *Symphorema polyandrum* (lf).

IVa. *Eranthemum purpurascens** (a), *Rungia*, *Hemigraphis*, *Justicia*, etc.

IVb. *Eulalia trispicata* (f), *Eulaliopsis binata* (lo), *Apluda mutica* (f).

(viii) *Angul Division, Orissa* (Preservation Plot No. 2)—

I. *Adina cordifolia* (16%), *Lagerstroemia parviflora* (14%), *Anogeissus latifolia* (10%), *Terminalia tomentosa* (4%), *Mitragyna parvifolia* (4%), *Dalbergia latifolia* (2·5%), *Hymenodictyon excelsum* (2·5%), *Bridelia retusa* (2·5%), *Albizzia* spp. (1·5%), *Salmalia malabarica* (1·5%), *Shorea robusta* (·5%), *Pterocarpus marsupium*, *Dalbergia paniculata*, *Protium serratum*, *Stereospermum suaveolens*, *Terminalia bellerica*, *Melia composita*, *Cleistanthus collinus* (40%), *Diospyros tomentosa*, *Lannea coromandelica*.

II. *Ougeinia oojeinensis*, *Cassia fistula*, *Alangium salvifolium*, *Careya arborea*, *Holarrhena antidysenterica*, *Cascaria tomentosa*, *Mallotus philippensis*, *Randia* spp., *Feronia limonia*, *Acacia leucophloea*, *Zizyphus xylopyrus*, *Chloroxylon swietenia*, *Gardenia latifolia*.

IIa. *Dendrocalamus strictus* (va).

III. *Helicteres isora*, *Strobilanthes*, *Moghania*, *Gardenia gummifera*.

IVb. *Cymbopogon martinii*, *Aristida setacea* etc.

V. *Combretum decandrum*, *Zizyphus oenoplia*, *Butea superba*, *B. parviflora*, *Millettia auriculata*, *Gouania leptostachya*, *Smilax* sp.

Percentages refer to all trees over 12·5 cm. d. b. h.

NOTE.—*Gardenia gummifera* is confined to clay schists (HAINES).

(ix) *Kalahandi, Orissa* (MOONEY).—

I. & II. *Anogeissus latifolia**, *Dalbergia latifolia*, *Pterocarpus marsupium*, *Stereospermum suaveolens*, *Spondias pinnata*, *Cleistanthus collinus*, *Acacia lanticularis*, *Flacourtia indica*, on drier rocks—*Boswellia serrata**, *Butea monosperma*, *Sterculia urens*, *Cochlospermum religiosum*, *Euphorbia nivulia*, on moisture slopes–*Adina cordifolia*, *Alangium salvifolium*, *Garuga pinnata*, *Hymenodictyon excelsum*, *Antidesma diandrum*.

IIa. *Dendrocalamus strictus*.

III. *Nyctanthes arbor-tristis*, *Flueggea obovata*, *Helinus lanceolatus*, *Ixora arborea*, *Justicia betonica*.

IVa. Ferns (*Cheilanthes tenuifolia*), *Eranthemum purpurascens**.

IVb. *Bothriochloa glabra*, *Apluda mutica*, *Heteropogon contortus*, *Themeda triandra*, *Themeda laxa** (l, va), *Eragrostis interrupta*.

(x) *M. P. (General floristics)*—

I. & II. *Anogeissus pendula** (va), *Acacia catechu* (a), *Anogeissus latifolia** (a), *Diospyros melanoxylon* (la), *Madhuca indica* (o), *Butea monosperma* (f), *Emblica officinalis* (f), *Feronia limonia* (o), *Albizzia* spp. (o), *Acacia leucophloea* (o), *A. arabica* (o), *Soymida febrifuga* (o), *Miliusa tomentosa* (o), *Bauhinia* spp. (o).

IIa. *Dendrocalamus strictus* (o).

III. *Carissa* sp. (f), *Flacourtia indica* (f), *Zizyphus xylopyrus* (f), *Zizyphus nummularia* (f), *Capparis decidua* (o), *Calotropis procera* (o), *Balanites aegyptiaca* (f), *Holarrhena antidysenterica* (f), *Grewia* spp. (f), *Adhatoda vasica* (f), *Gymnosporia spinosa* (f).

IVa. *Barleria prionitis* (f), *Achyranthes aspera* (f), *Cassia tora* (f), *Xanthium strumarium* (f), *Peristrophe bicalyculata* (f).

IVb. *Heteropogon contortus* (f), *Aristida depressa* (f), *Themeda quadrivalvis* (f), *Saccharum spontaneum* (la), *Cymbopogon martinii* (f), *Sehima nervosum* (o).

V. *Zizyphus oenoplia* (f), *Gymnema sylvestre* (r), *Acacia caesia* (f), *Abrus precatorius* (f), *Asparagus* spp. (r), *Gloriosa superba* (r), *Tinospora cordifolia* (r).

Epi. *Vanda** (r).

Par. *Cuscuta reflexa* (f), *Dendrophthoe falcata* (o).

(xi) *Biguri, S. Raipur Division, Madhya Pradesh.*—

I. *Terminalia tomentosa,* Anogeissus latifolia,* Diospyros melanoxylon,* Buchanania lanzan, Terminalia chebula, Cleistanthus collinus, Madhuca indica Boswellia serrata, Lagerstroemia parviflora.*

II. *Emblica officinalis, Zizyphus xylopyrus.*

III. *Phoenix acaulis, Woodfordia fruticosa.*

NOTE.—*Cleistanthus* occasionally forms nearly pure consociations.

(xii) *Chittorgarh Division, Rajasthan.*—

I. *Anogeissus latifolia** (a), *Boswellia serrata** (a), *Terminalia tomentosa* (f) *Sterculia urens* (o), *Lannea coromandelica* (c), *Diospyros melanoxylon* (c), *Albizzia odoratissima* (o), *Soymida febrifuga* (o), *Cassia fistula* (r), *Bridelia retusa, Bauhinia racemosa, Mitragyna parvifolia* (r), *Butea monosperma* (la), *Ficus* spp., *Dalbergia paniculata* (o).

II. *Acacia catechu* (a), *Acacia leucophloea* (f), *Nyctanthes arbor-tristis* (c), *Zizyphus mauratiana* (c), *Prosopis spicigera* (c), *Wrightia tinctoria, Flacourtia indica.*

IIa. *Dendrocalamus strictus* (o).

III. *Carissa spinarum, Zizyphus nummularia, Grewia* spp.

IVa. *Achyranthes aspera*, *Cassia* spp., *Acanthus* spp., *Atylosia* sp., *Sida* spp., *Securinega leucopyrus*, *Xanthium strumarium*.

IVb. *Bothriochloa pertusa*, *Arthraxon quartinianus*, *Apluda mutica*, *Heteropogon contortus*, *Eragrostis* spp., *Aristida* spp.

Par. Occasional *Cuscuta reflexa*, *Dendrophthoe falcata*.

(xiii) *Udaipur Division, Rajasthan.*—

I. & II. *Anogeissus latifolia*,* *Boswellia serrata*,* *Lannea coromandelica*, *Sterculia urens*, *Terminalia arjuna*, *Salmalia malabarica*, *Soymida febrifuga*, *Albizzia odoratissima*, *Acacia leucophloea*, *Emblica officinalis*, *Wrightia tinctoria*, *Mitragyna parvifolia*.

III. *Holarrhena antidysenterica*, *Vitex negundo*, *Woodfordia fruticosa*, *Jatropha* spp.

IVa. *Tridax procumbens*, *Cassia tora*, *Pavonia* spp., *Borreria hispida*.

IVb. *Chrysopogon* spp., *Apluda mutica*, *Eragrostis* spp.

NOTE.—Sometimes this type and the *Anogeissus pendula* type (p. 210) occur in close proximity with practically no transition. Generally, however, *Anogeissus latifolia* and *Anogeissus pendula* are not found together although their associates are in common. *Anogeissus latifolia* consociations are prominent on flat tops in association with *Boswellia*, *Lannea*, *Acacia catechu*, and on southern aspects with *Boswellia*, *Sterculia* and *Nyctanthes*.

GENERAL NOTE.—Transition forms are extensively developed and are particularly characteristic of the central plateau region. Examples from Orissa, Madhya Pradesh and southern Rajasthan illustrate the floristic shifts in comparison to the southern types.

DEGRADATION STAGES OF DRY DECIDUOUS FORESTS

The following stages are recognised :

DS1—Dry deciduous scrub

DS2—Dry savannah forest

DS3—(*Euphorbia* scrub)

DS4—(Dry grassland)

DS1. Dry deciduous scrub

DESCRIPTION.—A low broken soil cover of shrubby growth 3 to 6 m. high including some tree species reduced to similar conditions, usually many stemmed from the base. Some bamboo is often present. Many of the shrubs are distasteful to cattle (*Holarrhena*, *Dodonaea*) or thorny (*Randia*, *Carissa*). Thin grass occurs throughout. It is possible but not necessary to distinguish northern and southern forms.

DISTRIBUTION.—Throughout the dry deciduous forest zone of India.

LOCALITY FACTORS.—There may be localities in which the soil and climate are such as to permit of the development of a dry deciduous low forest in which tree growth in the narrower sense is scarce, but all examples examined seem unquestionably to owe their stunted condition to maltreatment, usually directly or indirectly connected with felling, lopping, grazing and frequent fires. Even dry teak forests may be reduced to this stage with many stemmed crooked branchy teak stocks (4 to 6 shoots), amidst *Zizyphus nummularia, Balanites* or *Salvadora* scrub near villages, as in southern Rajasthan.

FLORISTICS.—

(i) *Kangra, Punjab.*—

I. *Nyctanthes arbor-tristis,* Dodonaea viscosa,* Woodfordia fruticosa,* Carissa opaca,* Flacourtia indica, Lannea coromandelica, Aegle marmelos, Cassia fistula, Acacia catechu.*

NOTE.—On dry Siwalik hill sides.

(ii) *Gaya Hills, Bihar.*—

Acacia catechu, Butea monosperma, Randia dumetorum, Carissa opaca,* Acacia pennata.*

(iii) *Kahudag, Bihar.*—

Acacia catechu, Flacourtia indica, Euphorbia, Zizyphus, Carissa,* Mimosa.*

(iv) *Sambalpur, Orissa.*—

I. *Chloroxylon swietenia, Acacia catechu, Zizyphus xylopyrus, Gardenia gummifera,* G. turgida, G. resinifera, Cleistanthus collinus,* Boswellia serrata, Terminalia tomentosa.*

NOTE.—On horizontal shales with very shallow infertile soil—more or less a savannah form.

(v) *Banswara, Rajasthan.*—

I. & II. *Acacia leucophloea,** (c), *Salvadora oleoides* (c), *Phoenix sylvestris* (o), *Holoptelea integrifolia* (r), *Balanites aegyptiaca* (la).

III. *Zizyphus nummularia, Euphorbia nivulia, Holarrhena antidysenterica, Cassia auriculata* (a).

IVa. *Leptadenia pyrotechnica, Cassia tora* (o), *C. occidentale* (r), *Ocimum americanum.*

IVb. *Aristida hystrix, Eragrostis unioloides, Eragrostis* spp., *Melanocenchris jacquemontii, Andropogon pumilus* etc.

V. Almost absent except seasonal *Cucurbitaceae* climbers in *Euphorbia* bushes.

(vi) *Digwal, Hyderabad, Andhra Pradesh.*—

*Gymnosporia** (a), *Dodonaea** (a), *Randia** (a), *Bauhinia racemosa* (o), *Buchanania lancifolia* (f), *Butea* (a), *Mimosa* (f), *Acacia catechuoides* (f), *A. arabica* (o), *Zizyphus mauratiana* (f), *Ixora arborea* (f), *Anona squamosa.*

(vii) *Mansurabad, Andhra Pradesh.*—

Scattered *Acacia leucophloea**, *Bauhinia racemosa*, *Dalbergia paniculata*, *Wrightia tinctoria*, *Zizyphus xylopyrus*, *Cassia fistula*, *Randia**, *Anona**, *Heteropogon contortus*, *Eragrostis* spp.

(viii) *Mysore plateau.*—

Coppice shoots of dry deciduous forest species, i.e., *Tectona* (dry teak), *Pterocarpus*, *Albizzia*, *Terminalia*, *Chloroxylon*, *Hardwickia* etc. with thorny species *Atalantia monophylla**, *Flacourtia*, *Dichrostachys**, *Randia**, *Acacia chundra**.

(ix) *Southern Mysore plateau.*—

Albizzia lebbek, *A. amara*,* *Chloroxylon swietenia*, *Acacia chundra*, *Azadirachta indica*, *Zizyphus mauratiana*, *Z. oenoplia*, *Dichrostachys cinerea*,* *Euphorbia antiquorum**, *Pterolobium indicum*; in stonier places *Gyrocarpus jacquinii**, *Sterculia urens*, *Cochlospermum religiosum*, *Commiphora caudata**, *Givotia rottleriformis*; occasionally *Hardwickia*, *Feronia limonia*, *Commiphora*, *Givotia* and *Dendrocalamus strictus*.

(x) *Motebennur, Mysore.*—

Butea, *Hardwickia*, *Cassia auriculata*,* *Lantana*,* *Dodonaea*,* *Cymbopogon* spp.

General Note.—A considerable variety of degenerate forests could be included here but the above examples are fairly representative. Some of them are the result of long continued maltreatment, of which grazing and lopping may be the chief factors, or fuel and pole fellings may be equally influential. Others are regrowth after a period of cultivation and may have grown up under more or less heavy grazing. Savannah types with scattered bushes and low trees among grass are very common.

DS2. Dry savannah forest

DESCRIPTION.—The usual open but typical formation is lost and the trees stand far apart singly or in small groups in more or less heavy grass in which certain fire resistant plants persist, either slowly establishing themselves as trees, or sending up annual shoots from a woody rootstock. Stemless *Phoenix* is particularly characteristic. The trees have very short poles and are usually crooked and unsound or hollow. Thorny shrubs are common.

DISTRIBUTION.—Throughout the dry deciduous forests.

LOCALITY FACTORS.—Those of the general type combined with over exploitation, heavy grazing and usually annual burning.

FLORISTICS.—

(i) *Singhbhum, Bihar.* 600—900 m. (MOONEY).—

I.& II. *Gardenia turgida** (o), *Eugenia caryophyllifolia* (o), *Acacia lenticularis* (r), *Emblica officinalis* (o).

III. *Woodfordia fruticosa*, *Combretum nanum* (o), *Crotalaria hirta* (f), *Conyza* spp. (f), *Blumea* spp. (o), *Dysophylla* spp. (o).

IVb. *Themeda triandra** (va), *T. quadrivalvis* (a), *Apluda mutica** (a), *Arundinella setosa* (la), *Cyperus niveus.*

(ii) *Kalahandi, Orissa.* Laterite plateau at about 1000 m. (MOONEY).—

I. & II. *Emblica officinalis**(c), *Bauhinia retusa, Dillenia, Careya, Elaeodendron.*

IVb. *Arundinella setosa** (va), *Cymbopogon martinii* (a), *Themeda triandra* (a).

General Note.—This type occurs fairly extensively on the Central Indian hills at about 1000 m.

(iii) *Motebennur, Mysore.*—

I. *Hardwickia binata,* Butea monosperma.*

III. *Cassia auriculata, Dodonaea viscosa, Lantana camara.*

IVb. *Cymbopogon* sp. (va).

(iv) *Eastern Madras.*—

I. *Pterocarpus marsupium, Anogeissus latifolia*, Bridelia retusa, Terminalia chebula, Emblica officinalis.*

III. *Phoenix humilis*.*

IVb. *Cymbopogon coloratus* (dominant).

Note.—Further degradation leads to a form in which only a few *Pterocarpus, Bridelia* and *Emblica* stand over dense grass, mainly *Cymbopogon coloratus, Themeda triandra* and *Heteropogon contortus*, with abundant *Phoenix humilis.*

(v) *Shorea talura savannah, Madras.*—

I. *Shorea talura,* S. tumbuggaia,* Pterocarpus santalinus, P. marsupium, Anogeissus latifolia, Diospyros melanoxylon.*

III. *Phoenix humilis.*

IVb. Dense grass.

ECOLOGICAL STATUS.—Nearly all the climatic types described can be reduced to open savannah form. These types are shown as degradation stages consequent on intense biotic interference as it is considered that the climatic climax has a more or less complete tree and shurb canopy with grass growth a definitely subordinate feature. The grass becomes conspicuous wherever the canopy is broken and is favoured against other forms of vegetation by burning, lopping and grazing. As the conditions which lead to the development of savannah forest render it more xerophytic than corresponds to the climate, the savannah derivatives of the moist tropical forests approximate those of the dry tropical areas.

DS3. (Euphorbia scrub)

This type is described under the Thorn forests, cf. 6B/DS1 on page 242.

(*DS4.* Dry grassland)

According to DABADGHAO (1960), the dominant grass cover in the dry deciduous zone is *Sehima-Dichanthium* type, the characteristic perennial species being:

(i) Hills & hill slopes—

Sehima nervosum, Chrysopogon fulvus, Themeda triandra, Eremopogon foveolatus, Heteropogon contortus, Cymbopogon spp.

(ii) Plateau and valleys, deep soils—

Dichanthium annulatum, Bothriochloa pertusa, Eremopogon foveolatus, Cynodon dactylon.

Deteriorated grasslands are characterised by the presence of several annual species chiefly *Heteropogon contortus* (annual form), *Aristida* spp., *Melanocenchris jacquemontii, Eragrostis* spp., *Chloris* spp., *Alloteropsis cimicina, Andropogon pumilus, Urochloa panicoides* etc. The subcovers typical of degraded stages are six : *Cymbopogon* (cf. DS2, page 208), *Chrysopogon, Bothriochloa, Heteropogon, Eremopogon—Aristida, Eragrostis—Melanocenchris.*

EDAPHIC CLIMAX TYPES IN DRY DECIDUOUS FORESTS

The following edaphic types are specifically recognised :

E1—Anogeissus pendula forest

DS1—Anogeissus pendula scrub

E2—Boswellia forest

E3—Babul forest

E4—Hardwickia forest

E5—Butea forest

E6—Aegle forest

E7—Laterite scrub forest

E8—Saline-Alkaline scrub savannah

E9—Dry bamboo brakes

General Note.—Many of the tree species of the mixed deciduous forests are capable of forming more or less pure consociations. This tendency is emphasized in the dry forests by the harsher environmental conditions, climatic, edaphic and biotic, to which the forest is usually subject, so that greater demands are made on the specific adaptability of constituent elements leading to pure groups and local dominance. Among species forming such consociations in addition to *Anogeissus pendula, Boswellia serrata, Butea monosperma, Hardwickia binata, Aegle marmelos, Phoenix sylvestris, Salvadora, Acacia arabica* treated in greater detail as distinct edaphic climaxes, the following may be mentioned being undoubtedly of edapho-biotic status although details are lacking.

Xylia xylocarpa, Pterocarpus marsupium (moister fascies).

Diospyros tomentosa, Terminalia chebula, Anogeissus latifolia, Cleistanthus collinus (dry fascies).

Acacia senegal, Albizzia amara, Cochlospermum religiosum (very dry fascies).

E1. Anogeissus pendula forest

DESCRIPTION.—The type is largely determined by the presence of *Anogeissus pendula* which forms nearly pure crops, often quite well stocked, about 6 m. high and 70—80 cm. girth, but branched from about 1-1.5 m. above the ground. The associated species are those of the southern dry deciduous type with more and more of the thorn forest species as the habitat is drier. The forest is leafless from March to June. There is a thin shrub and grass undergrowth but no bamboo.

DISTRIBUTION.—Aravalli hills in Rajputana, Ajmer-Merwara, Bundelkhand northwards to Jhansi and Banda, and southwards to the Narmada in Nimar and the Panch Mahals. (TROUP).

LOCALITY FACTORS.—

Temperature and Rainfall.—The climate is typically hot as for representative stations in Uttar Pradesh and Rajasthan. There are great extremes of temperature. The rainfall may be as low as 400 mm. or as high as 950 mm.

Soil and Topography.—The type usually occurs on the lower and gentler slopes and tops of low hills (*Boswellia* or *Sterculia urens* occupying the higher ridges and crests) within the 240-600 m. altitudinal range. The rock is crystalline or metamorphic or sandstone, rarely limestone. The soil is gravelly reddish loam, rather shallow, more clayey on lower reaches and level ground.

ILLUSTRATION.—Plate 46.

FLORISTICS.—

General—

It generally forms pure or markedly gregarious associations, the common associates being *Acacia leucophloea* and *A. senegal* in the western part of the range.

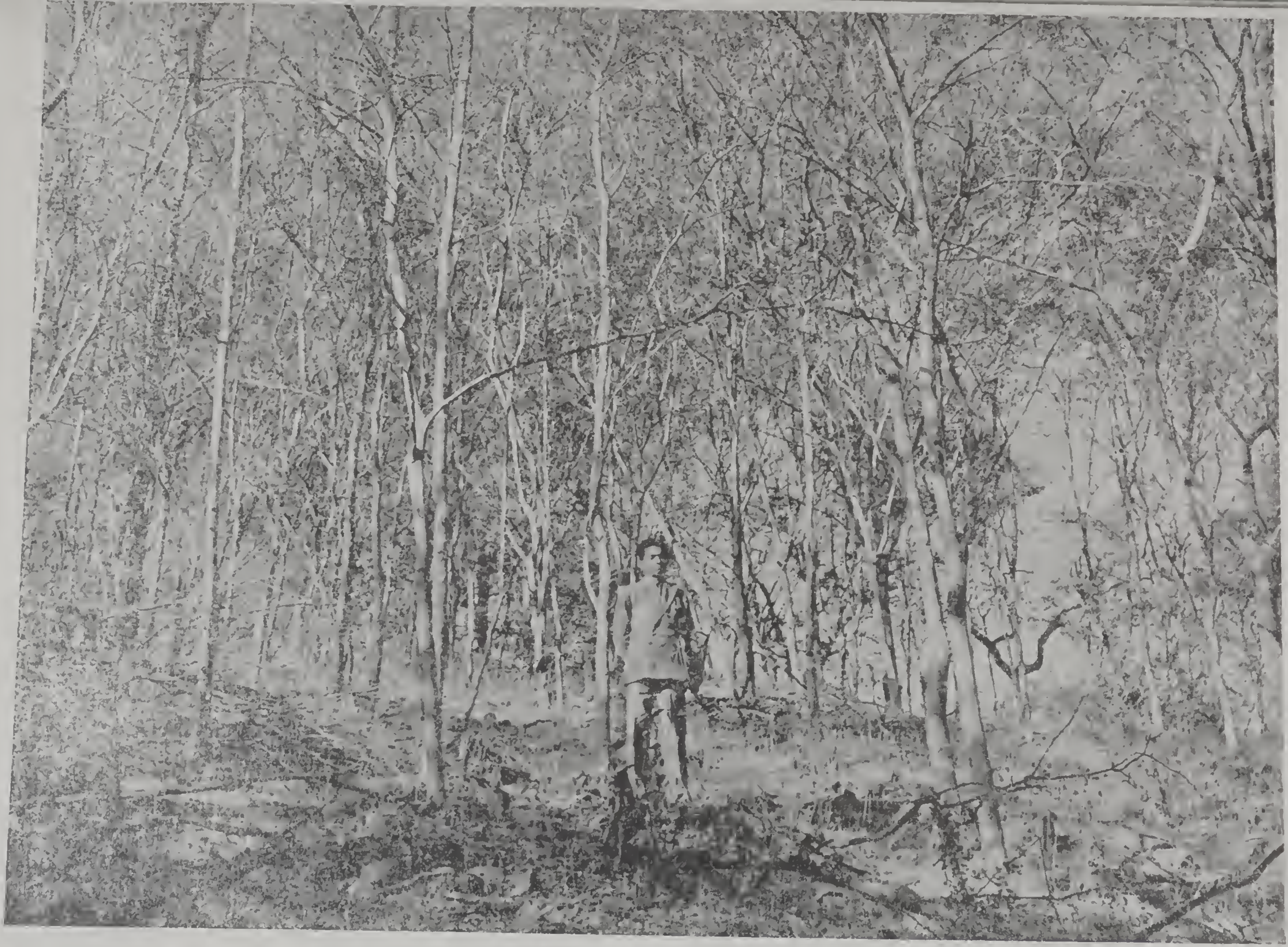
(i) *Jhansi Division, U. P.*—

I. & II. *Anogeissus pendula,* Acacia catechu, Anogeissus latifolia, Lagerstroemia parviflora, Diospyros tomentosa, Aegle marmelos, Zizyphus glaberrima, Bauhinia racemosa, Lannea coromandelica, Butea monosperma.*

(ii) *Ajmer, Rajasthan.*—

I. & II. *Anogeissus pendula,* Boswellia serrata*, Acacia catechu, A. rupestris, Albizzia odoratissima, Dalbergia lanceolaria, Dichrostachys cinerea, Bauhinia racemosa, Grewia.*

NOTE.—*Boswellia* as usual tends to occupy the ridge crests whilst *Acacia rupestris* replaces the *Anogeissus* on the poorest soils (TROUP).



ANOGEISSUS PENDULA FOREST

Close canopied forest on ridge crest. Shahabad (near Fortress), Rajasthan.

G. S. Mathauda

(iii) *Chittorgarh Fort forest, Chittorgarh Division, Rajasthan* (SAXENA).—

I. *Anogeissus pendula** (va) (95%), *Acacia leucophloea** (c), *Diospyros cordifolia* (c), *Sapindus emarginatus* (o), *Acacia catechu* (r), *Butea monosperma* (o), *Azadirachta indica* (r), *Ficus glomerata* (r), *Lannea coromandelica* (o), *Sterculia urens* (r), *Boswellia serrata* (r), *Tamarindus indica* (r), *Albizzia odoratissima* (o), *Schrebera swietenioides* (r).

II. *Dichrostachys cinerea* (f), *Wrightia tinctoria*, *Zizyphus mauratiana*, *Grewia tenax* (c), *Securinega leucopyrus* (c).

III. *Adhatoda vasica* (la) (particularly on fringes), *Capparis sepiaria*, *Lepidagathis cristata.*

IVa. *Cassia tora*, *Indigofera cordifolia*, *Borreria hispida*, *Argemone mexicana* (r), *Aerva javanica*, *Leucas* spp., *Acanthus* spp., *Malvaceae* spp., *Tridax procumbens.*

IVb. *Aristida hystrix*, *Chloris dolichostachya*, *Eragrostis* spp., *Apluda mutica*, *Chrysopogon fulvus*, *Cymbopogon* spp., *Eremopogon foveolatus*, *Heteropogon contortus*, *Oplismenus* spp.

V. Practically absent except for a few *Abrus precatorius.*

NOTE.—The crop has been under protection for over 100 years and is in excellent condition. Stocking is good and the average height is 7·5 m. and average girth about 50 cms. It is on a northern aspect on sandstone and quartzite. *Boswellia* etc. occur on the top of the hill and *Diospyros cordifolia* is particularly found on the forest fringes. *Oplismenus* is most common where the canopy is closed.

(iv) *Dungarpur, Banswara Division, Rajasthan.*—

I. *Anogeissus pendula** (va), *Acacia leucophloea** (a).

II. Almost nil; *Flacourtia sapida* (o), on the outskirts *Dichrostachya cinerea*, *Gymnosporia spinosa*, *Grewia flavescens*, *Capparis decidua*, *Zizyphus mauratiana*, *Balanites aegyptiaca*, *Butea monosperma.*

III. *Mimosa rubicaulis*, *Ocimum americanum*, *Pavonia* spp.

IVa. *Cassia tora*, *Acanthus* spp.

IVb. *Oplismenus compositus* (a), *Eragrostis ciliaris*, *Chloris inflata*, on drier ground *Apluda mutica*, *Themeda triandra.*

V. *Capparis* (o).

NOTE.—This area has been under the Rajah's protection for a very long time and is on good soil. The *Anogeissus pendula—Acacia leucophloea* association is found almost to the exclusion of all other species except *Flacourtia*, *Capparis* and *Oplismenus*. The canopy is fully closed; the *Anogeissus* being about 11 m. high, 45 cms. girth; *Acacia leucophloea* about 11 m. high, 1.1 m. girth.

(v) *Badnor, Udaipur Division, Rajasthan.*—

I. & II. *Anogeissus pendula,* Boswellia serrata,* Acacia catechu, A. senegal, Albizzia odoratissima, Dalbergia lanceolaria, Dichrostachys cinerea, Bauhinia racemosa.*

IIa. *Dendrocalamus strictus* (o).

III. *Grewia flavescens, G. tenax, Rhus mysorensis, Cassia auriculata.*

IVa. *Vernonia* spp., *Andrographis* spp., *Lycium europaeum.*

IVb. *Apluda mutica, Heteropogon contortus, Sehima nervosum, Aristida hystrix.*

V. Absent.

General Note.—This association links the northern and southern forms of the dry deciduous and both with the thorn forest. It is apparently an edaphic climax because although it occurs on various geological formations and different types of soil, under complete protection for over 100 years it has maintained itself and is also regenerating naturally.

It may be noted that both *Anogeissus pendula* and *Acacia catechu* occur in fairly extensive nearly pure stands as well as in intimate mixture and it is difficult to recognize any factor determining which of the two should predominate.

E1/DS1. Anogeissus pendula scrub

When browsing pressure is heavy, especially by goats, the *Anogeissus* is reduced to spreading and creeping forms sometimes forming prostrate cushions looking like topiary work. This is the last stage of degradation before it is totally eliminated. The illustration gives a better idea of the form than any description.

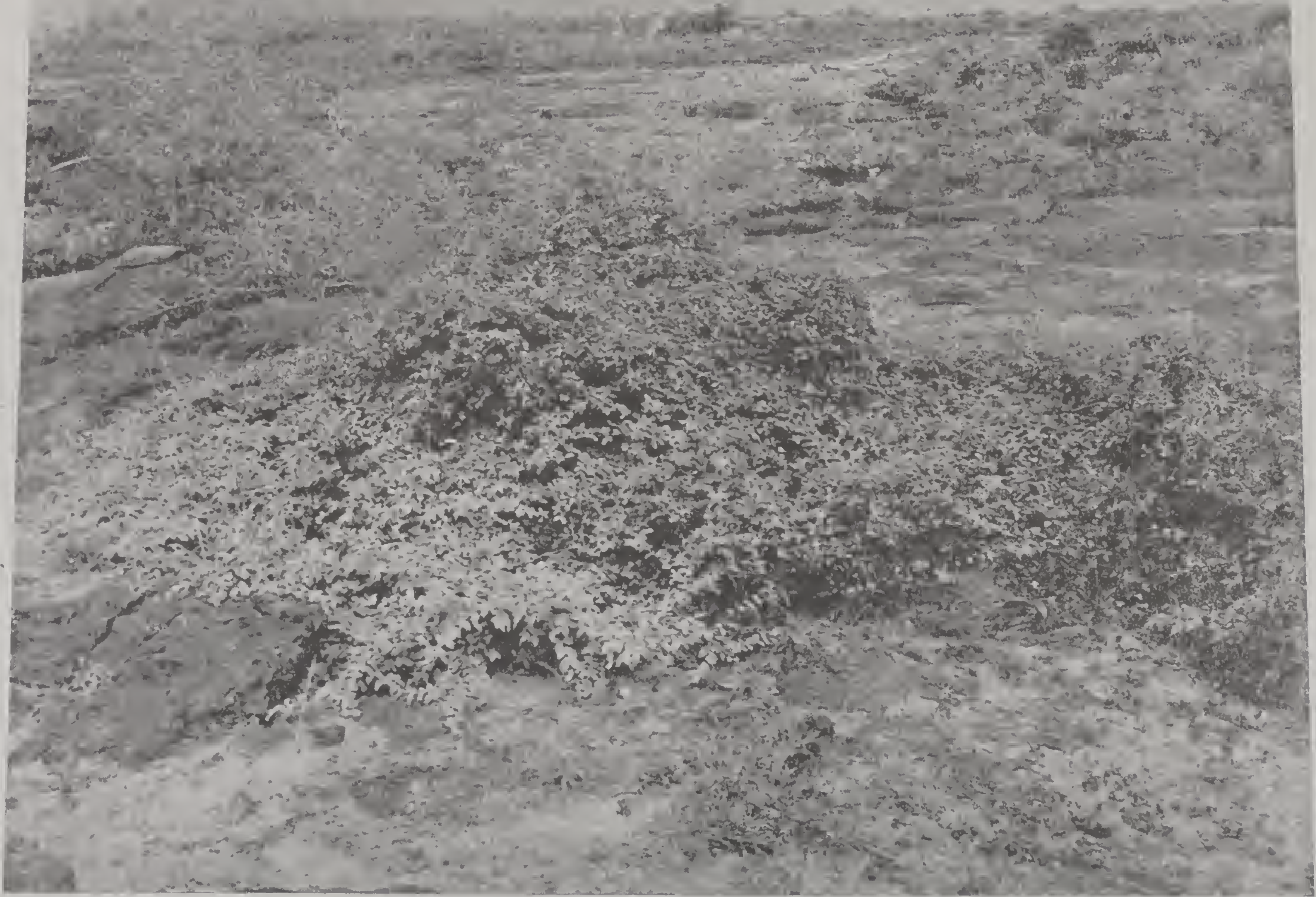
ILLUSTRATION.—Plate 47.

E2. Boswellia forest

DESCRIPTION.—An open forest in which *Boswellia* forms an overwood to stunted trees and shrubs of dry deciduous forests. Sometimes almost pure consociations of well grown mature trees or pole crops occur, especially on the flatter tops of Satpura range. It is ordinarily 12-15 m. exceptionally 18-20 m. high and 1.2 to 1.8 m. in girth, the only tree equally it in size often being *Sterculia urens.* Teak, wherever it occurs in association, is generally stunted. It is leafless from February to May. Bamboo may occur but is usually absent. There is low grass, scanty undergrowth and the forests are usually burnt. Regeneration is usually absent.

DISTRIBUTION.—On dry plateaux and hills throughout peninsular India. There is a distinct, more or less pure, continuous belt about 13 km. wide, on the higher reaches of Satpuras in Khargone Division, Madhya Pradesh.

LOCALITY FACTORS.—Rainfall 500 to 1,300 mm. with a long hot dry season. The type occurs on a variety of rocks, particularly crystalline, sometimes lateritic rocks, trap and shales. The soil is usually bouldery or pebbly, shallow and dry. Hill tops, ridges and spurs, and well drained plateaux are the usual sites.



ANOGEISSUS PENDULA SCRUB

A close cropped cushion of *Anogeissus* as an adaptation to excessive goat browsing.

Keotifalls, Rewa Division, Madhya Pradesh.

S. K. Seth

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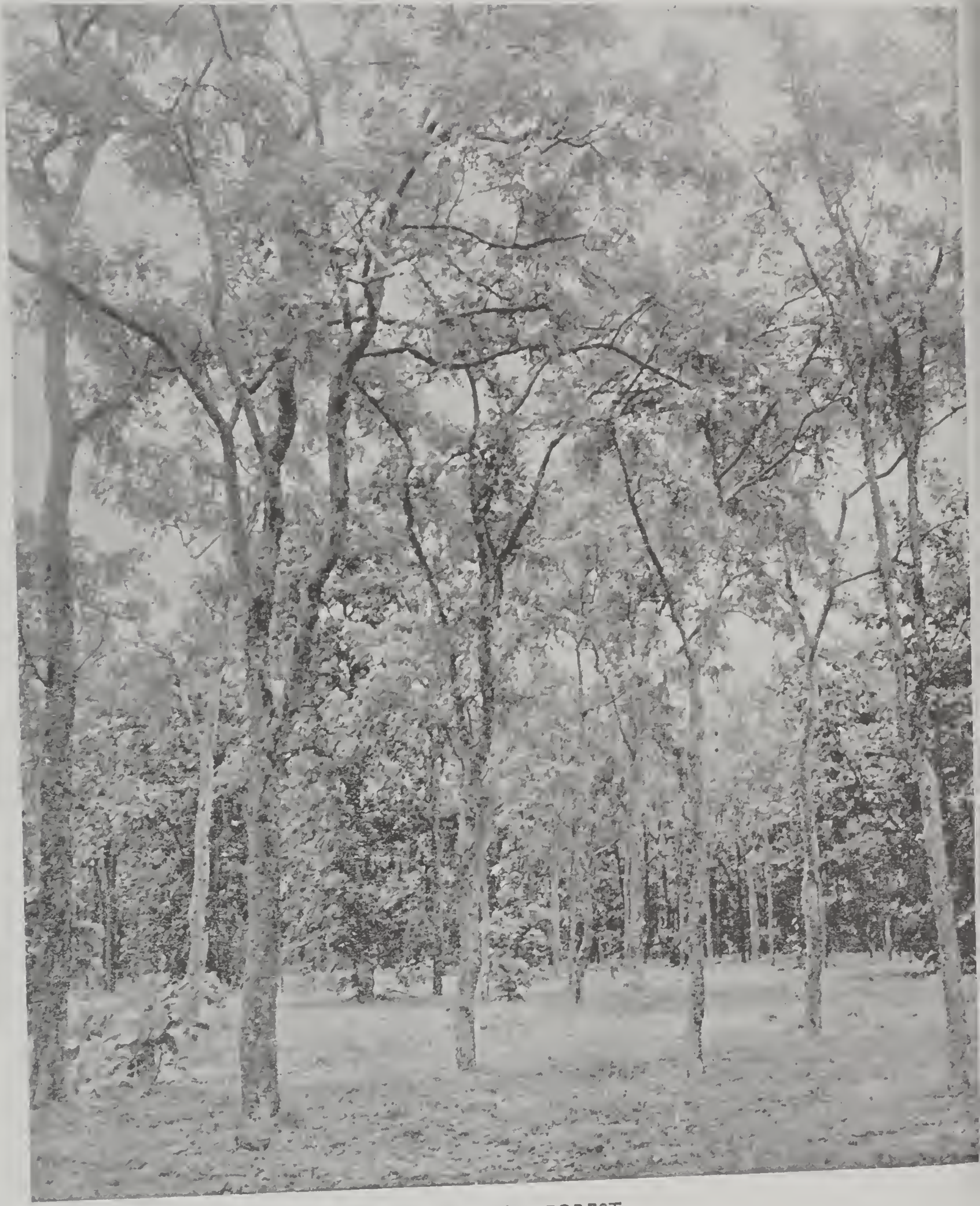


BOSWELLIA FOREST

A good quality natural pole crop of *Boswellia* on flat plateau. Lachminagar, Kannod Division, Madhya Pradesh.

S. K. Seth

ILLUSTRATION.—Plate 48.

FLORISTICS.—

(i) *Khargone Division, Madhya Pradesh.*—

I. *Boswellia serrata*,* *Tectona grandis, Lannea coromandelica, Hardwickia binata. Terminalia tomentosa, Hymenodictyon excelsum, Sterculia urens.*

II. Sparse—*Acacia catechu, Anogeissus latifolia, Bauhinia malabarica.*

IIa. *Dendrocalamus strictus* (lo).

III. Sparse—*Nyctanthes arbor-tristis.*

(ii) *Nimar, Madhya Pradesh.*—

I. *Boswellia serrata*,* *Acacia catechu, Cochlospermum religiosum, Lannea coromandelica, Commiphora mukul* (o).

IIa. *Dendrocalamus strictus* (l).

(iii) *Seoni Division, Madhya Pradesh.*—

I. *Boswellia serrata*,* *Cochlospermum religiosum, Sterculia urens, Lagerstroemia parviflora, Emblica officinalis.*

III. Practically no shrubs.

IVb. Grass very light.

(iv) *Baretha, Betul Division, Madhya Pradesh.*—

I. *Boswellia serrata** (a), *Buchanania lanzan* (o), *Lagerstroemia parviflora* (o), *Soymida febrifuga* (r), *Terminalia tomentosa* (f).

II. *Nyctanthes arbor-tristis* (la), *Diospyros melanoxylon* (f), *Emblica officinalis* (f). *Ougeinia oojeinensis* (f), *Acacia catechu* (o), *Bauhinia racemosa* (o).

IV. Very little grass or herbs.

(v) *Sarwan Deri Block, Banswara Division, Rajasthan* (SAXENA).—

I. & II. *Boswellia serrata** (a), *Lannea coromandelica* (f), *Sterculia urens* (r), *Terminalia tomentosa* (c), *Soymida febrifuga* (r), *Ougeinia oojeinensis* (c), *Diospyros tomentosa* (c), *Anogeissus latifolia* (c), and stunted *Tectona grandis* (r).

IIa. *Dendrocalamus strictus* (in cooler situations).

III. *Nyctanthes arbor-tristis, Holarrhena antidysenterica.*

IVa. *Cassia tora, Euphorbia hirta, Evolvulus alsinoides, Tridax procumbens, Sida* spp.

IVb. *Themeda quadrivalvis, T. triandra, Chrysopogon gryllus, Heteropogon contortus, Apluda mutica, Melanocenchris jacquemontii, Andropogon pumilus, Eragrostis* spp., *Aristida depressa.*

V. Climbers nil.

Par. *Dendrophthoe falcata* commonly parasitises *Boswellia.*

(vi) *Baghana, Udaipur Division, Rajasthan.*—

I. & II. *Boswellia serrata,* Lannea coromandelica, Sterculia urens, Anogeissus pendula* (at the lower limit of the *Boswellia* zone).

III. Occasional *Grewia* spp.

IVa. *Borreria hispida, Euphorbia hirta.*

IVb *Apluda mutica. Heteropogon contortus, Chrysopogon fulvus, Sehima nervosum.*

V. Absent.

General Note.—A very stable form on special sites, extended by maltreatment as *Boswellia* is usually left standing when other trees are felled and as it is very fire resistant. It does not coppice well. It often only forms a narrow strip on ridges in the dry teak forests, to which it would often probably progress or revert with long continued fire protection.

E3. Babul (Acacia arabica) forest

DESCRIPTION.—The general appearance of the forest is entirely dominated by the one species *Acacia arabica* which is markedly gregarious in habit and forms a denser cover than usual in thorn forest. Biotic factors have also undoubtedly been in play. The few associated species occur mainly where the *Acacia* canopy is broken, and there is usually very little undergrowth. There is a rather thin cover of grass. Grazing is usually very heavy.

DISTRIBUTION.—Best developed in Berar but met with elsewhere under similar conditions, e.g., in Poona Division, Maharashtra.

LOCALITY FACTORS.—This type is associated with black cotton soil. The climatic data given for Akola on pp. 227 are representative, those for Amraoti and Buldhana being very similar.

ILLUSTRATION.—Plate 49.

FLORISTICS.—

(i) *Berar, Maharashtra* (VAHID)—

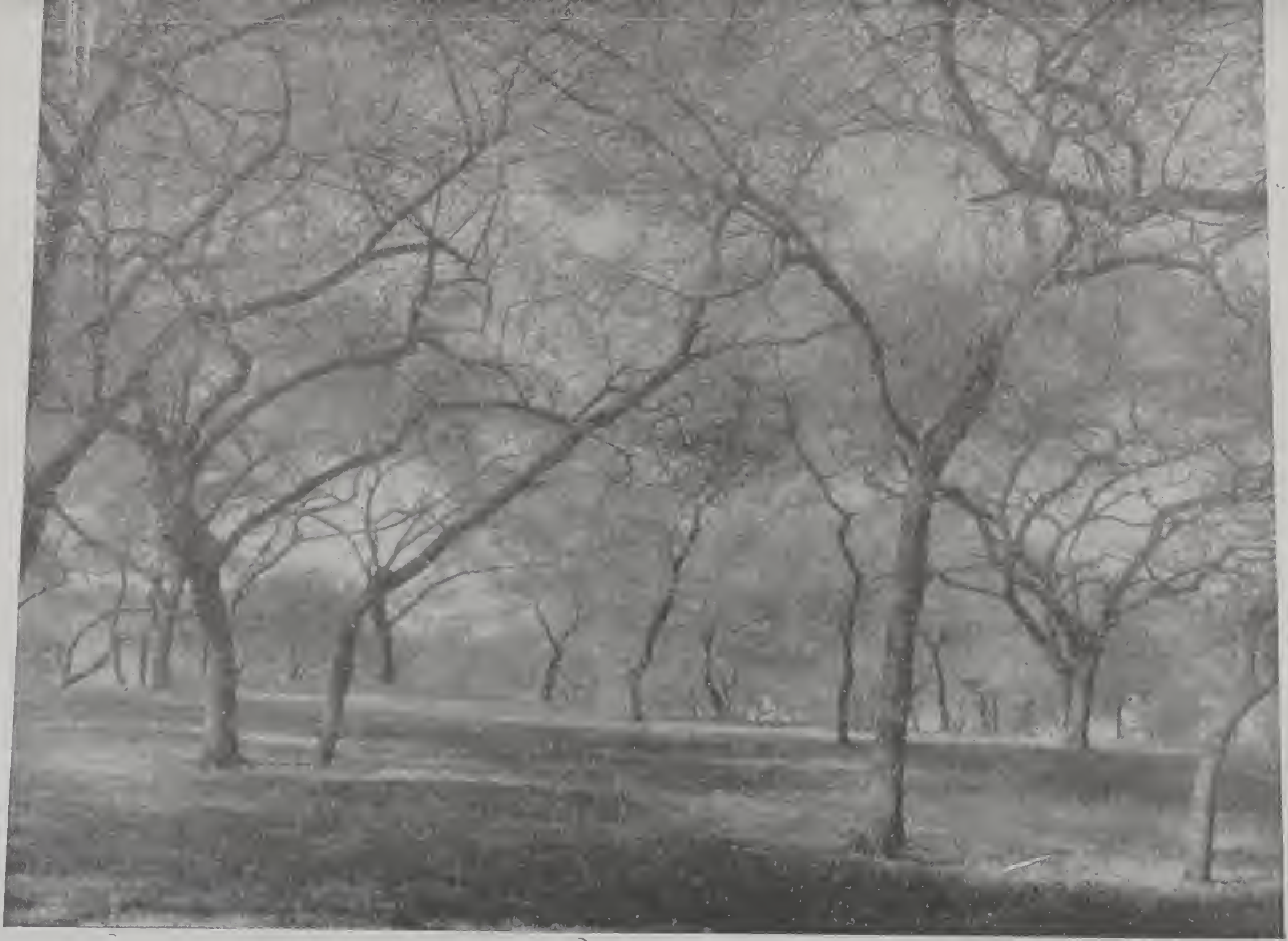
I. & II. *Acacia arabica, A. eburnea, Balanites aegyptiaca, Dichrostachys cinerea, Acacia leucophloea, Prosopis spicigera, Zizyphus vulgaris, Phoenix sylvestris* (wet ground), *Azadirachta indica.*

III. *Cassia auriculata, Capparis grandis.*

IVa. *Cassia tora.*

IVb. *Heteropogon contortus, Ischaemum pilosum, Chrysopogon fulvus, Dichanthium annulatum* etc.

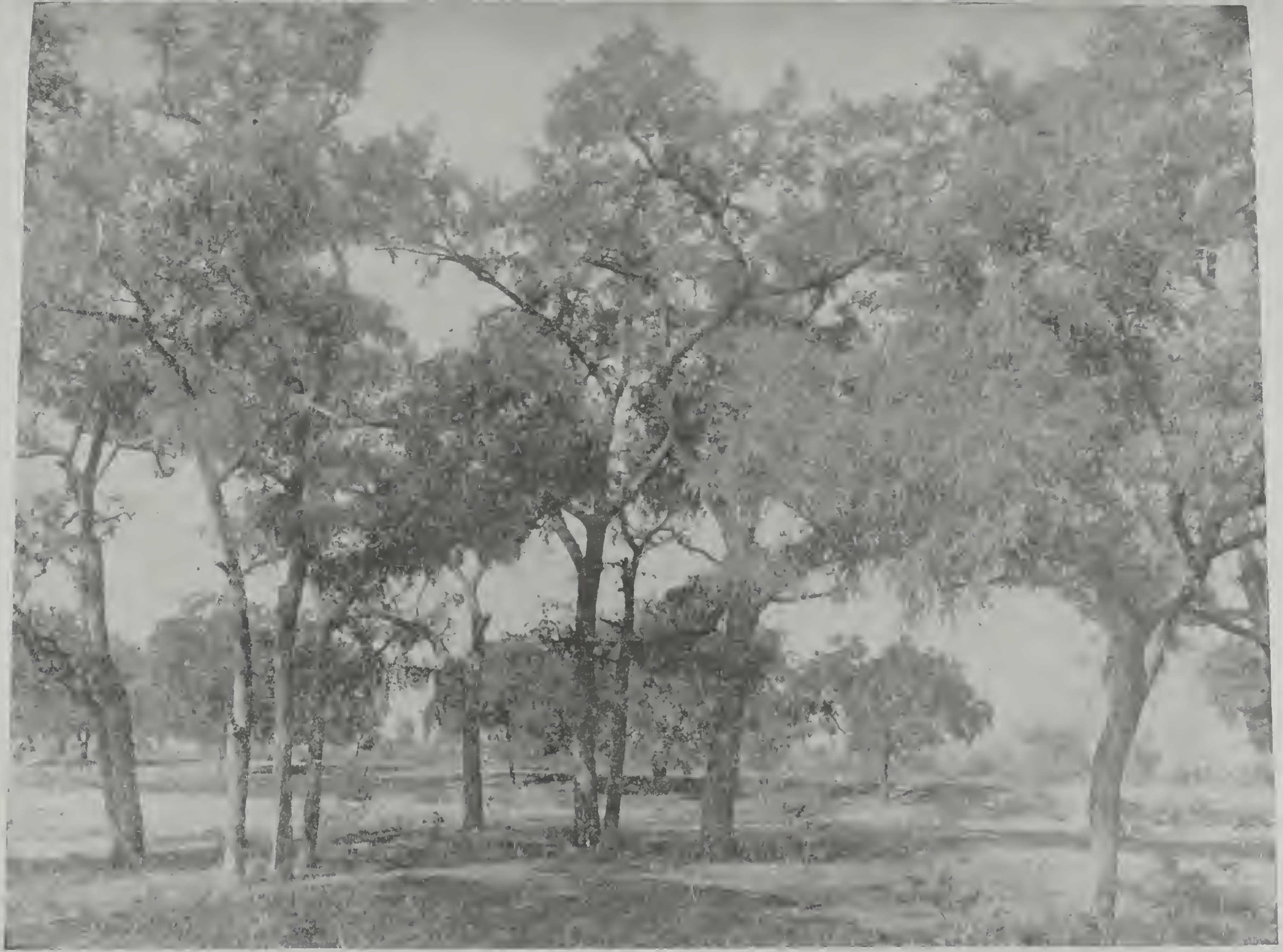
Note.—The Berar forests have undoubtedly been fundamentally altered by human influences, but the type is a well defined one.



BABUL FOREST

Pure *Acacia arabica* on black cotton soil, subject to heavy grazing. Lontek, Amraoti Division, Maharashtra.

H. G. Champion



HARDWICKIA FOREST
Residual group of *Hardwickia binata*, with *Cassia auriculata* and other unpalatable shrubs.
Dhulia, West Khandesh Division, Maharashtra.

H. G. Champion

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E4. Hardwickia forest

DESCRIPTION.—The forest has the general appearance of the group but the predominance of *Hardwickia binata* which is nearly evergreen and of different habit from its associates gives it a character of its own. Most forests have been much maltreated, grazed and burnt. Pure consociations are often found within the dry deciduous type akin to but much more restricted than consociations of dry teak.

DISTRIBUTION.—Scattered in blocks and patches in the drier parts of the peninsula from the Satpuras (Khargone, Kannod Divisions, Madhya Pradesh) through Maharashtra (Khandesh, Nasik) southwards throughout the plateau region of Andhra Pradesh and Mysore down to Salem in Madras.

LOCALITY FACTORS.—Rainfall 500 to 1000 mm. The distribution of the type has not yet been satisfactorily correlated with climatic and soil conditions although edaphic influences seem to predominate. It is most characteristic of shallow hard gravelly soils over trap but occurs on a variety of other rocks though then more mixed with other trees.

ILLUSTRATION.—Plate 50.

FLORISTICS.—

(i) *Barwani, Khargone Division, Madhya Pradesh.*—

I. & II. *Hardwickia binata** (70%), *Boswellia serrata, Lannea coromandelica, Anogeissus latifolia, Albizzia lebbek, Lagerstroemia parviflora, Diospyros tomentosa, Tectona grandis, Acacia catechu.*

IIa. *Dendrocalamus strictus* (o).

NOTE.—Similar floristics are found in Khandesh, Maharashtra, with a *Cassia auriculata* undergrowth. The *Hardwickia* trees in better areas attain 1·5 m. girth and 25 to 30 m. height but a dense pole crop is usual. On the poorer areas the crops is purer but rarely exceeds 15 m. in height.

(ii) *S. Cuddapah, Andhra Pradesh* (P.P. 3).—

I. *Hardwickia binata**.

II. *Acacia chundra.*

III. *Zizyphus* sp., *Mimosa* sp.

(iii) *Tirupati Hills, Andhra Pradesh.*—

I. & II. *Hardwickia binata**, *Pterocarpus santalinus, P. marsupium, Chloroxylon swietenia, Terminalia chebula, T. tomentosa, Albizzia lebbek, Dalbergia latifolia*, etc.

E5. Butea forest

DESCRIPTION.—On flat ground this type presents a savannah appearance with scattered stunted and very malformed trees or thickets standing over short grass or bare ground ; on lower hill slopes almost pure consociations are found on screes and gravel derived from basic rocks and yielding clayey soils. Sometimes found as a conspicuous association in degraded forests, e.g. *Butea-Cassia* in Kutch.

DISTRIBUTION.—Locally wherever soil conditions are suitable throughout the dry deciduous and the moister and of the Thorn forests.

LOCALITY FACTORS.—Stiff badly drained clay soils or very dry clayey soils, and particularly black cotton soils in illdrained flats and depressions and at the foot of hills are characteristic of this type.

ILLUSTRATION.—Plate 51.

FLORISTICS.—

(i) *Saraswati plantations (Ambala), Punjab.*—

I. *Butea monosperma** in pure patches ; occasional *Ficus religiosa, Acacia leucophloea, Acacia arabica, Salvadora oleoides, Capparis sepiaria, C. decidua, Zizyphus mauratiana, Z. nummularia.*

IVa. *Suaeda fruticosa* (in saline patches).

IVb. *Vetiveria zizanioides, Desmostachya bipinnata, Erianthus munja, Cynodon dactylon, Eleusine* sp., *Sporobolus marginatus* (in saline/alkaline patches).

(ii) *Chittorgarh Division, Rajasthan* (SAXENA).—

I. & II. *Butea monosperma*(a), Acacia leucophloea* (f), *Prosopis spicigera* (c).

III. *Zizyphus mauratiana* (c), *Z. nummularia* (c), *Tephrosia purpurea, Mimosa rubicaulis.*

IVa. *Indigofera cordifolia, Acanthaceae, Compositae.*

IVb. *Apluda mutica, Heteropogon contortus, Iseilema laxum* (c), *Bothriochloa pertusa.*

General Note.—*Butea* is often found in small patches in valley types of forests through the entire region particularly in the teak and *Anogeissus pendula* type where it is usually associated with *Terminalia* and *Syzygium.*

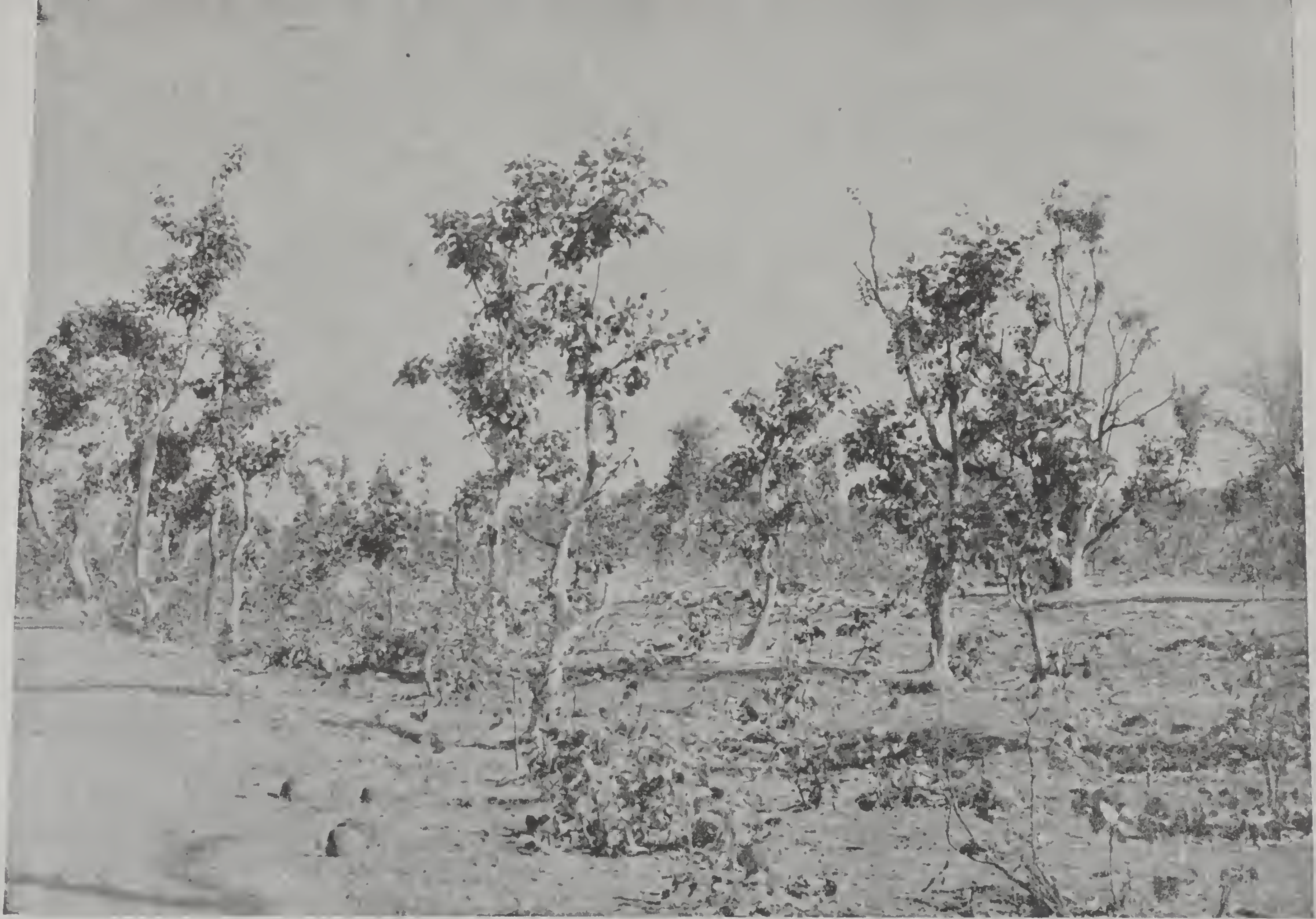
This is a pronounced edaphic subtype though sometimes it occurs due to maltreatment in dry deciduous and *Acacia* scrub forests.

E6. Aegle forest

DESCRIPTION.—An open dry deciduous forest in which *Aegle marmelos* predominates often forming nearly pure consociations. It is only leafless for a short period.

DISTRIBUTION.—In the dry deciduous and the drier part of the moist deciduous tracts being well represented in Gonda and Bahraich divisions of Uttar Pradesh. Palamau division in Bihar and Chitter division of Rajasthan.

LOCALITY FACTORS.—Typically on stiff dry clayey alluvial soils, which sometimes (e.g. Motipur and Chakia in Bahraich Division, U.P.) often contain manganese nodules. The sites are frequently elevated, usually well drained, and water logging does not occur.



BUTEA FOREST

Pure *Butea monosperma* on badly drained soil; lopped for lac cultivation. Warseoni, Balaghat Division, Madhya Pradesh.

M. V. Laurie

ILLUSTRATION.—TROUP; Fig. 69.

FLORISTICS.—

(i) *Motipur and Chakia, Bahraich Division, U.P.*—

*Aegle marmelos**, *Diospyros tomentosa*, *Zizyphus glaberrima*, *Acacia catechu*, *Adina cordifolia*, *Lannea coromandelica*, *Shorea robusta*.

(ii) *Semalpur forest, Chittorgarh Forest Division, Rajasthan* (SAXENA).—

I. & II. *Aegle marmelos**, *Acacia catechu*.
III. *Mimosa rubicaulis*, *Nyctanthes arbor-tristis*.
IVa. *Compositae* spp.
IVb. *Heteropogon contortus*, *Aristida* spp., *Apluda mutica*.
V. No climbers.

NOTE.—This type extends over 200 ha. in this block.

GENERAL NOTE.—The type occurs as islands in dry sal or inferior moist sal forest in which it is said to be encroaching and indicates signs of progressive dessication *Aegle* has great powers of reproduction by rootsuckers. These forests form a well defined edaphic climax.

E7. Laterite scrub

NOMENCLATURE.—Kerala—*Mesophytic* scrub. (DAVIS).

DESCRIPTION.—Irregular open scrub of stunted trees of deciduous habit, sometimes with thorny species dominating, with thin undergrowth including xerophytic evergreens.

DISTRIBUTION.—On the west coastal plains from Kanara down-wards to Kerala.

LOCALITY FACTORS.—The climate is that of the semi-evergreen or even evergreen forest, but the type is determined by the dry shallow soil which is usually hard laterite, probably exposed, denuded and hardened by human influences.

FLORISTICS.—

(i) *N. Kanara, Mysore* (ARORA).—

I. *Terminalia chebula*, *Careya arborea*, *Santalum album* (o).
II. & III. *Gardenia**, *Pavetta*, *Ixora coccinea*, *Glochidion*, *Flacourtia indica*, *F. montana*, *Osyris wightiana*, *Randia dumetorum**, *Canthium dicoccum*.
V. *Dalbergia sympathetica*, *Jasminum malabaricum*, *Celastrus paniculata*, *Zizyphus* spp.

(ii) *N. Mangalore Division, Mysore.*—

I. *Acacia chundra**, *Litsea wightiana**, *Buchanania lanzan*, *Lannea coromandelica*, *Anacardium occidentale* (planted or natural).
II. *Santalum album*, *Gardenia gummifera*.

NOTE.—There is an obvious resemblance to the Southern thorn forest (cf. p. 231).

(iii) *Kerala* (CHANDRASEKHARAN).—

I. & II. Stunted trees of *Terminalia tomentosa*, *T. paniculata**, *Careya arborea*, *Emblica officinalis*, *Strychnos nux-vomica**, *Buchanania lanzan*, *Lannea coromandelica*, *Bridelia retusa*, *Tectona grandis* (o), *Butea monosperma*.

III· *Calycopteris floribunda*, *Carissa* sp., *Dodonaea viscosa*, *Combretum* sp., *Zizyphus* sp., *Holarrhena antidysenterica*, *Randia* sp., *Pavetta* sp., *Calotropis* sp.

IVa. *Cassia tora*, *Sida rhombifolia*, etc.

E8. Saline/alkaline scrub savannah

DESCRIPTION.—Irregular semi-savannah growth, occasionally dominated by single tree species, patches of low tree and shrub growth alternating with grassy areas or bare soil covered with white efflorescence (where salt concentration is very high).

DISTRIBUTION.—Throughout the Indo-Gangetic plains and locally in valley in the peninsular region.

LOCALITY FACTORS.—The climate is that associated with the dry deciduous forests. The soil is alluvial, usually clayey, occasionally with a stiff clay or concretionary lime pan not much below the surface, with saline/alkali salts concentrated in the upper layers. External and internal drainage are both usually restricted.

SUB-DIVISIONS.—

Differences in locality factors chiefly topographic and edaphic necessitate recognition of the following subtypes.

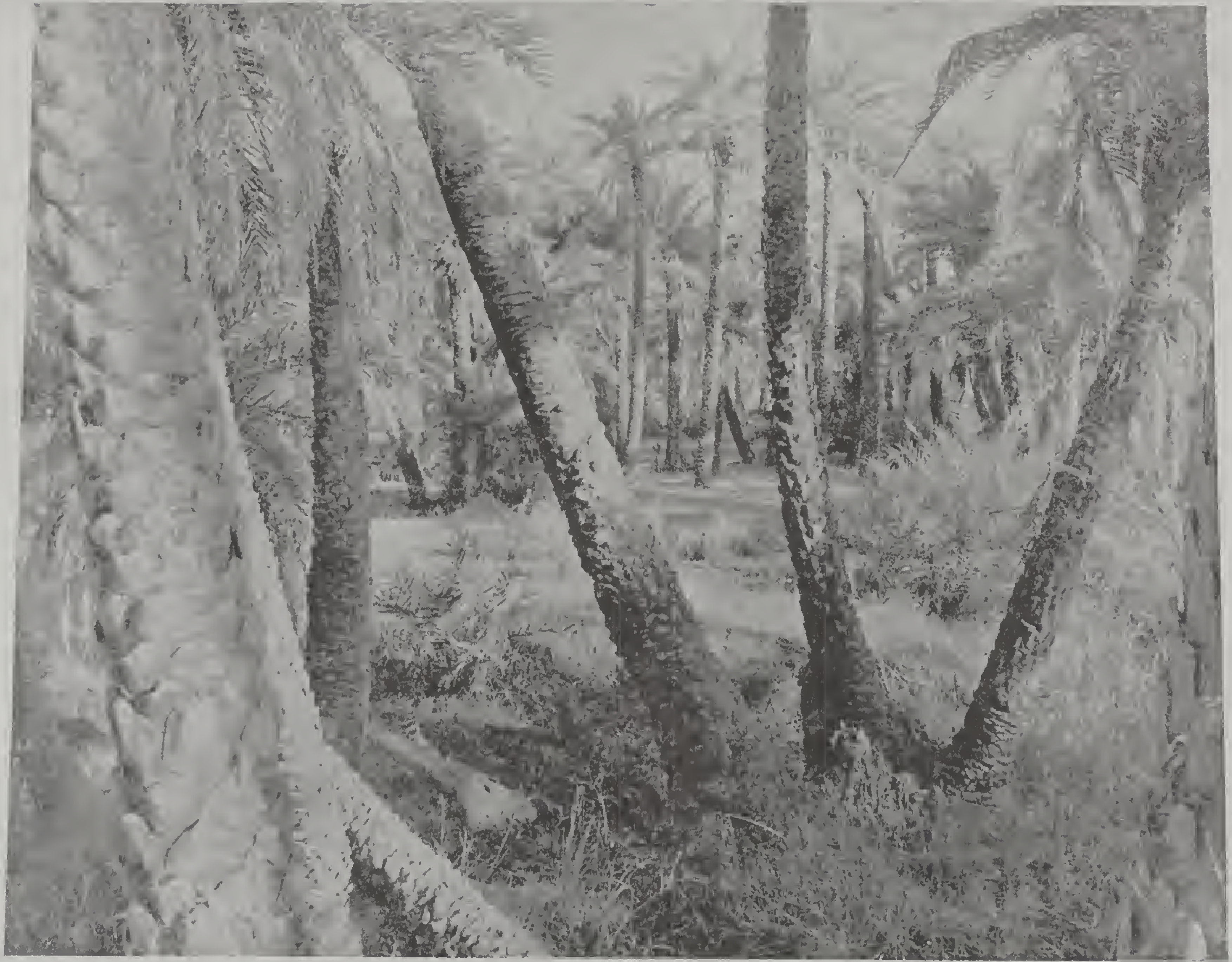
a—*Phoenix savannah*.

b—*Babul savannah*.

c—*Salvadora-Tamarix scrub*.

E8a. Phoenix savannah

Phoenix sylvestris occurs as pure gregarious riparian fringing vegetation on narrow alluvial deposits along streams, or over much more extensive lowlying areas adjacent to large rivers, the common attribute often being the clayey (and locally *usar*) nature of the top soil and periodic inundation leading to temporary or more frequently prolonged water-logging. It is thus found along many smaller streams in Punjab, Uttar Pradesh (even along water-logged canals), Madhya Pradesh etc. and conspicuously in the Ganges *Khadar* (low-lying recent alluvium). It is occasionally associated with *Butea monosperma*, *Carissa opaca*, *Capparis*, *Salvadora* etc. *Imperata cylindrica*, *Desmostachya bipinnata* and *Vetiveria zizanioides* are the common grasses.



PHOENIX SAVANNAH

Phoenix sylvestris along low lying land near stream banks. Indore, Madhya Pradesh.

S. K. Seth

In Southern India *Borassus flabellifer* often occupies an identical niche in the general habitat, either by itself or mixed with *Phoenix sylvestris*.

ILLUSTRATION.—Plate 52.

E8b. Babul savannah

In the old alluvium region of Punjab and Uttar Pradesh and elsewhere in northern India extensive patches of *usar* land occur, characterised by high saline/alkaline conditions (with or without a lime pan). Similar conditions are developed in the black cotton soil region in the peninsula. The characteristic vegetation is an open savannah with scattered trees and a few bushes over low grass. The ground is bare where the concentration of salts is excessive.

FLORISTICS.—

Uttar Pradesh—

I. & II. *Acacia arabica* (o), *Acacia leucophloea* (r), *Butea monosperma** (c), (Lowlying areas) *Azadirachta indica* (l), *Salvadora oleoides*, *S. persica*.

III. *Capparis decidua* (o), *C. sepiaria* (o).

IVa. *Aeschynomene indica*, *Murdannia nudiflorum*, *Cyanotis axillaris**, *Corchorus aestuans*, *Portulaca oleracea*, *P. tuberosa*, *Oldenlandia diffusa*, etc.

IVb. Grasses : *Sporobolus marginatus** (va), *Chloris montana** (la), *Cynodon dactylon** (la), *Aristida hystrix*, *Desmostachya bipinnata*, *Paspalidium flavidum*.

Sedges : *Alysicarpus bupleurifolius*, *Cyperus aristatus*, *C. compressus*.

E8c. Salvadora-Tamarix scrub

In western Uttar Pradesh, Punjab, Rajasthan, Saurashtra etc. the saline/alkaline soils support a *Salvadora-Tamarix* community corresponding to the *Acacia* community of the moister regions to the east. *Acacia arabica* occurs in specially favourable situations; elsewhere *Salvadora oleoides*, occasionaly *S. persica* and locally *Tamarix aphylla* form characteristic associations. The usual undergrowth is *Calotropis procera*, *C. gigantea*, *Capparis decidua*, *Indigofera* sp. and locally *Tamarix dioica*, *Suaeda fruticosa* and *Salsola foctida*.

FLORISTICS.—

Karnal, Punjab—

I. *Acacia arabica*, *Prosopis spicigera* (both occasional), *Tamarix aphylla*,* *Salvadora oleoides**, *S. persica*.

II. *Capparis decidua*, *C. sepiaria*, *Zizyphus mauratiana*, *Randia* sp

III. *Calotropis procera*, *C. gigantea*, *Kochia indica*.

IVa. *Suaeda fruticosa*, *Salsola foetida* (on saline soils).

IVb. *Sporobolus marginatus*, *Cenchrus barbatus*, *Eleusine compressa*, *Dactyloctenium aegyptium*, *Tragus biflorus*.

E9. Dry bamboo brakes

DESCRIPTION.—Only one species, *Dendrocalamus strictus*, occurs and forms relatively low (rarely over 7 m.) but often dense brakes. Where grazed, etc. the bamboo grows in dense patches with the grass and deciduous often thorny shrub between. A scattered overwood of the hardier species of the dry deciduous forest may indicate the dominance of the bamboo to be only secondary. Sometimes there is practically no overwood.

DISTRIBUTION.—Throughout the dry deciduous type in India, with marked local preponderance. Good examples occur in Punjab (Hoshiarpur), Uttar Pradesh (Lansdowne), Bihar (Palamau etc.), Rajasthan (Banswara), Gujarat (Vijara), in most divisions of Madhya Pradesh, Maharashtra and Mysore, in Madras (Salem) etc.

LOCALITY FACTORS.—Occurs mainly on dry hillsides but also on alluvium with rainfall of 900 mm. or rather more. The soil is dry most of the year and often shallow and stony as well.

ILLUSTRATION.—Plate 53.

FLORISTICS.—

(i) *General*

*Dendrocalamus strictus** with a sprinkling of the tree and shrub species of the local form of dry deciduous forest, thus in C. and S.India teak, *Boswellia serrata*, *Sterculia urens* and *Cochlospermum religiosum*, in N. India *Anogeissus latifolia* and *Lannea coromandelica*.

NOTE.—Biotic factors certainly influence the occurrence of this bamboo brake and the absence of trees may often be due to them, but apparently natural examples also occur appearing to be associated with soil conditions.

For a comprehensive account please see DEOGUN (1937).

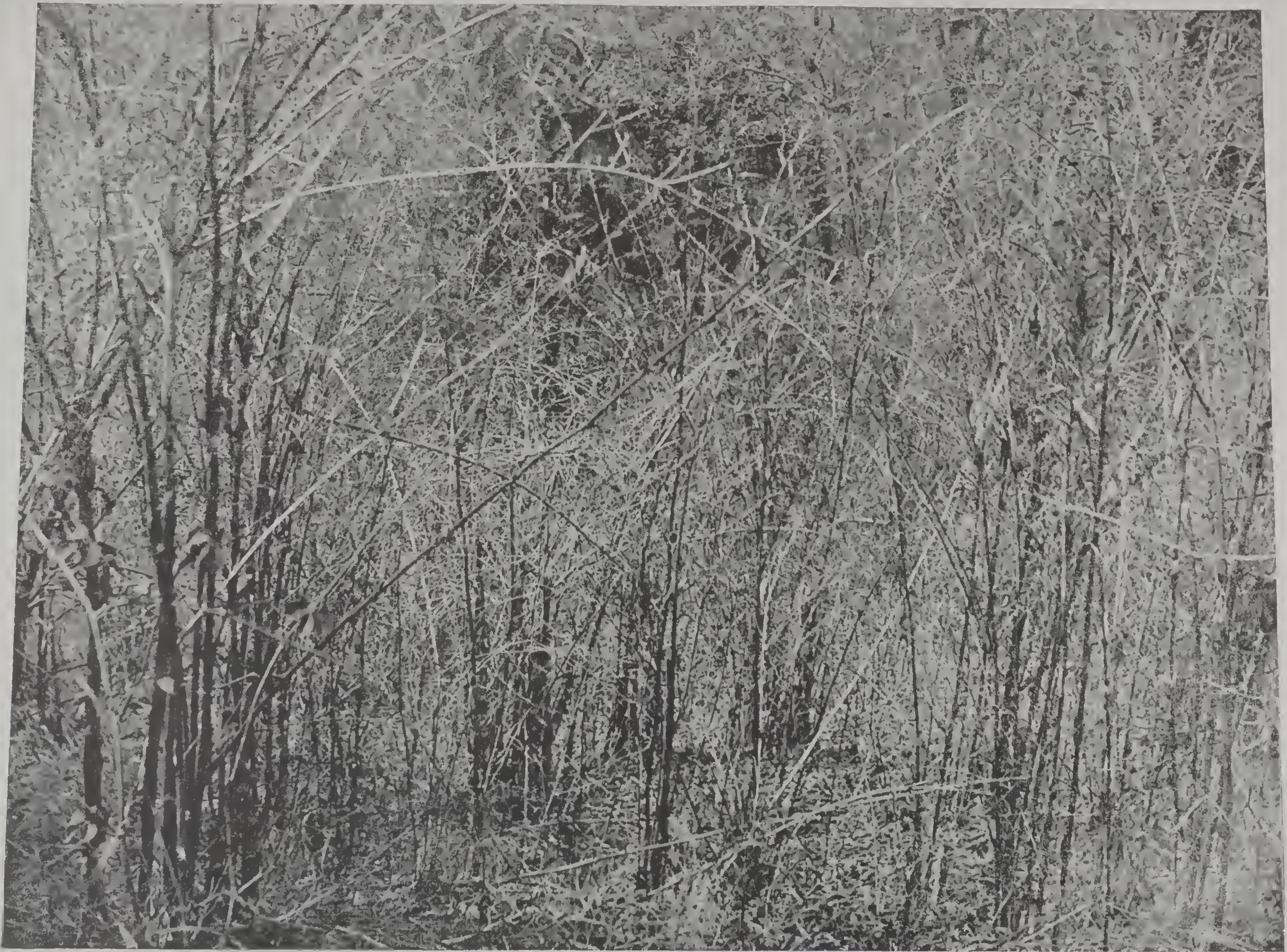
SERAL TYPES OF DRY DECIDUOUS FORESTS

PRIMARY SERAL TYPES

1S1 *Dry tropical riverain forest.*

1S2 *Khair-Sissu forest.*

1S3 *Inundation babul forest.*



DRY BAMBOO BRAKES

Dense *Dendrocalamus strictus* brakes. Lansdowne Division, Uttar Pradesh.

Basti Ram

SECONDARY SERAL TYPES

2*S*1 *Secondary dry deciduous forest.*

PRIMARY SERAL TYPES

1S1. Dry tropical riverain forest

DESCRIPTION.—An irregular overwood of greater height than the climax dry deciduous forest, and the trees often being of larger size and forming patches and strips with varying amounts of smaller trees and shrubby undergrowth. The foliage is more or less evergreen in several of the chief dominants. The soil is often bare sand, which may first be colonised by shrubs or grass.

DISTRIBUTION.—Narrow strips along the hilly sections of the larger streams in the dry deciduous forests widening as the valleys get broader and extending into the moist deciduous types also.

LOCALITY FACTORS.—A light sandy soil often overlying more or less impervious rock (Deccan trap being typical) liable to be temporarily submerged during the short monsoon period, and usually retaining adequate water supplies most of the year. Air temperatures must be relatively high owing to radiation from the exposed rock and sand.

ILLUSTRATION.—cf. Plate 37.

FLORISTICS.—

(i) *Mahi river, Banswara Division, Rajasthan.* (After SAXENA).—

I. & II. *Eugenia heyneana* (f), *Terminalia arjuna** (f), *Holoptelea integrifolia* (o).

III. *Tamarix dioica* (la), *Vitex negundo* (la), *Typha angustifolia* (la).

IVa. *Compositae, Borreria hispida, Sarcostemma parvifolia.*

IVb. *Cynodon dactylon, Cyperus* spp. (sedge).

V. No climbers.

NOTE.—On higher ground the more xerophytic element of the typical flora of the region develops, *e.g. Zizyphus nummularia, Calotropis procera, Capparis decidua, Cassia auriculata, Tephrosia purpurea* among shrubs, and low shrubs and herbs like *Sarcostemma parvifolia, Borreria hispida*, and grasses such as *Eragrostis tremula, Cenchrus* spp., *Apluda* etc. There are no climbers.

(ii) *Wainganga/Wardha river junction, S. Chanda Division, Maharashtra.*—

I. *Terminalia arjuna** (a), *Anogeissus acuminata* (f), *Mitragyna parvifolia* (o).

II. *Pongamia pinnata* (*a*), *Barringtonia acutangula, Alangium salvifolium* (a), *Bauhinia malabarica* (f), *Strebulus asper* (f), *Diospyros tomentosa* (o), *Butea monosperma, Strychnos nux-vomica* (o), *Tamarindus indica* (o), *Mallotus philippensis* (f).

III. *Helicteres isora* (o).

IVb. Very little grass.

V. *Derris scandens* (o), climbers very few.

NOTE.—The shrub consocies of *Homonoia* spp., *Tamarix dioica*, *Ficus* spp., *Eugenia heyneana, Vitex, Acacia jacquemontii*, etc. which grow in the actual river bed and are adapted to complete submersion, are met with in adjoining sites. These shrubs are characterised by long flexible branches which give to the moving water and usually by elongate simple leaves. The tree species occur on stabilised or rocky banks or in islands where pockets of firm soil exist.

1S2. Khair-Sissu forests

NOMENCLATURE.—The Hindustani names of the two characteristic trees are so well known that their use to designate the type is justified.

DESCRIPTION.—A deciduous forest in which *Dalbergia sissoo* predominates. The canopy is light but usually fairly complete and 18 to 25 m. high. *Acacia catechu* is usually but not always present, it does not grow as tall as the *Dalbergia* and in the mixture is often relatively inconspicuous, but sometimes it occurs pure. The older woods have more or less definite understorey which is mainly composed of young trees which will in time replace the *khair-sissu* as the natural succession takes place. There is often a dense deciduous shrubby undergrowth in the older woods still leaving much of the sandy soil exposed; the opener parts carry a few herbs of which *Cannabis sativa* is locally dominant and grass of one or two species among which the xerophytic *Saccharum spontaneum* is very characteristic. These woods have one marked feature in which they resemble the moist more than the dry deciduous in that they come early into leaf (March) and are in full leaf throughout the hot weather; this is, however, actually a specific character of the dominant *Dalbergia* not shared by most of its associates.

DISTRIBUTION.—Along all the larger rivers of N. India, on new sandy or gravelly alluvium in Punjab, Uttar Pradesh, Bihar, Bengal and Assam.

LOCALITY FACTORS.—The influence of the soil so far exceeds that of climate that the type is obviously the same from the Punjab to Assam as the first tree association to colonise new deposits. There is an ample water supply at a moderate depth though the upper soil may be very porous hot and dry during the summer and is almost devoid of humus. The soil is unstable and may be washed away at any time.

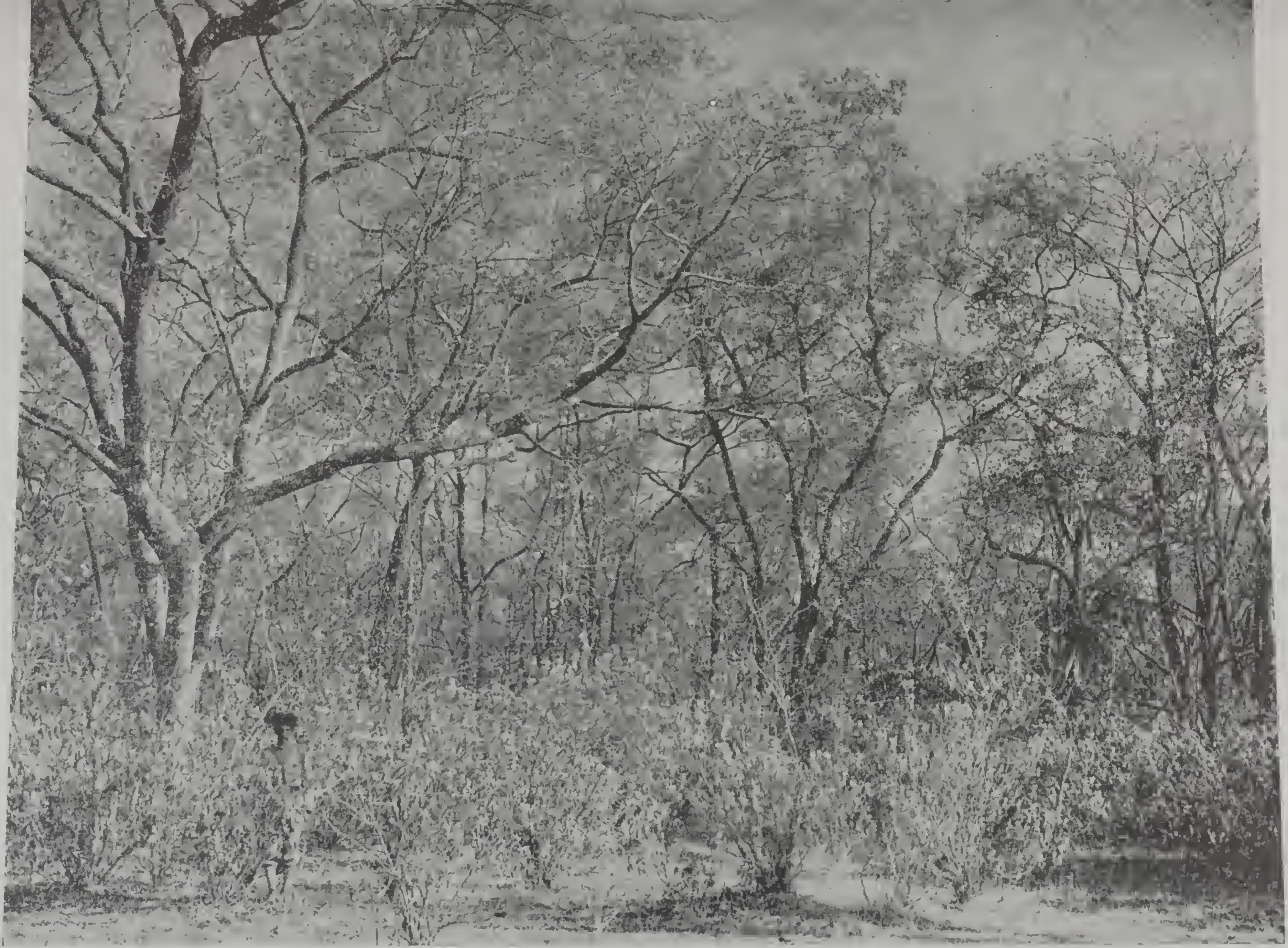
ILLUSTRATION.—Plate 54.

FLORISTICS.—

PURE KHAIR TYPE

(i) *Sonari block, Gorakhpur, U.P.*—

Acacia catechu, Tamarix dioica, Calotropis procera, Tiliacora acuminata.*



KHAIR-SISSU FOREST

Acacia catechu and some *Dalbergia sissoo* with *Holoptelea integrifolia* coming in beneath. Complete undergrowth of *Adhatoda vasica* mixed with *Helicteres isora*. Lachiwala, Dehra Dun Division, Uttar Pradesh. A. E. Osmaston

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PURE SISSU TYPE

(ii) *Punjab.*—

I. *Dalbergia sissoo.**

II. *Tamarix dioica, Acacia farnesiana* (nat.).

IVb. *Saccharum spontaneum, Erianthus munja.*

(iii) *Lansdowne Division, U.P.* (Preservation Plot No. 26, N.E. part).—

I. *Dalbergia sissoo** (pure).

IVa. *Cassia tora* (pure).

IVb. *Erianthus munja* (in open).

(iv) *Kalagarh Division, U.P.* (Preservation Plot No. 14).—

I. *Dalbergia sissoo** (pure).

III. *Cannabis sativa, Pogostemon plectranthoides, Grewia oppositifolia, Trema politoria.*

IVb. *Saccharum spontaneum, Chrysopogon fulvus, C. gryllus, Apluda mutica, Bothriochloa pertusa, Vetiveria zizanioides.*

(v) *Haldwani Division, U.P.* (Preservation Plot No. 12).—

I. *Dalbergia sissoo** (pure).

II. *Holoptelea integrifolia* (pure).

III. *Murraya koenigii.*

IVb. Light grass (Charkuti).

V. *Vallaris, Millettia.*

NOTE.—*Holoptelea* started coming in under *sissu* overwood when the latter was about 15 years old. There were 164 trees of *sissu* and 274 of *Holoptelea* in 1940 when the crop was about 35 years old. By 1960, at 55 years age all *sissu* had disappeared leaving pure *Holoptelea* overwood.

MIXED SISSU-KHAIR TYPE

(vi) *Ganges Islands, Lansdowne Division, U.P.*—

I. *Dalbergia sissoo,** *Acacia catechu.**

II. *Holoptelea integrifolia, Zizyphus mauratiana, Ehretia laevis.*

III. *Adhatoda vasica**, *Murraya koenigii, Helicteres isora, Calotropis procera.*

IVb. *Saccharum spontaneum, Erianthus munja, Aristida cyanantha.*

NOTE.—*Tamarix dioica* and naturalised *Acacia farnesiana* occur up the smaller tributaries.

(vii) *Sarda Islands, Haldwani Division, U.P.*—

I. *Dalbergia sissoo,** *Acacia catechu.**

II. *Holoptelea integrifolia, Breynia.*

III. *Adhatoda vasica, Pogostemon plectranthoides.*

IVb. *Saccharum spontaneum,** etc.

(viii) *Jaldapara, Cooch Behar Division, W. Bengal*, on new gravel and sand beds.

I. *Dalbergia sissoo,* Acacia catechu* (locally).

IVb. *Saccharum spontaneum.*

NOTE.—On older terraces *Salmalia malabarica*, *Albizzia procera* (a), *Bischofia javanica* (f) with *Acacia catechu* (la) *Dillenia* sp. (f), *Trema* sp. (o) are sprinkled over dense 4-5 m. high, *Saccharum procerum* with *Phragmites karka* (a), *Themeda arundinacea* (f) and *Imperata cylindrica* (lf). On older and higher ground occurs a wet mixed forest with a few sal and canes and ferns on the ground.

(ix) *Teesta River, W. Bengal.*—

I. *Dalbergia sissoo,* Acacia catechu,* Albizzia procera.*

II. *Premna* spp.

III. *Croton caudatus*, *Acacia* spp.

IVb. *Erianthus arundinaceus*, *E. ravennae* etc.

GENERAL NOTE.— *Tamarix dioica* sometimes precedes the *khair-sissu*, and the *Asclepiad*, *Orthanthera viminea* also forms societies on the gravel beds. In the moister climates to the east, the grass growth is heavier and includes big tufted species rarely seen in the west ; the succession is also much more rapid and even *Shorea robusta* may be found slowly getting a footing among the *Dalbergia* and *Saccharum spontaneum*.

Dalbergia sissoo never regenerates under a parent crop, and the species is completely displaced in the second tree generation. *Acacia catechu* is more persistent and is generally present in the next marked stage. *Holoptelea integrifolia* is not rarely found forming a complete underwood to *sissu* and ultimately replaces it as a pure crop particularly on bouldery soil. More generally, however, *Salmalia malabarica*, *Adina cordifolia*, *Albizzia procera*, *Moringa oleifera*, *Kydia calycina*, *Lagerstroemia parviflora*, *Gmelina* and other species with *Cedrela* wherever conditions are fairly moist and *Anthocephalus cadamba* in the east, find a footing, and as the *sissu* drops out, form a mixed deciduous forest which may progress further to moist sal forest, or to semi-evergreen according to climatic conditions. In Punjab, the progression is in the other direction to the local dry climatic types. Cf. SMYTHIES, 1921.

1S3. Inundation babul forest

DESCRIPTION.—A fairly complete canopy 10 to 15 m. high formed by practically pure crops of *Acacia arabica*. As the level is raised and the soil gets drier, the species of the climax type represented by *Prosopis spicigera*, *Acacia leucophloea* and occasionally *Acacia catechu* (persisting and stabilised from the seral stage) appear. There may be scattered shrubs of *Zizyphus* spp., *Carissa opaca* etc. and dense short grass.

DISTRIBUTION.—Along the larger streams in Maharashtra and C. India; locally in N. India.

LOCALITY FACTORS.—The river generally begins to rise at the beginning of May and the rise continues with some interruptions till about the middle or end of July and sometimes later. Thereafter it generally subsides and reaches its winter level about the end of October. Actual flooding for about 6 weeks is necessary for good development. There is, however, a great deal of variation from year to year and erosion and deposition is constantly in progress. Fires are likely to occur in the heavy grass from December to May. Grazing is usually very heavy.

FLORISTICS.—

(i) *Doaba Block, Bahraich Division, U. P.*—

I. *Acacia arabica**.

IVb. Grass abundant.

NOTE.—*Acacia catechu, Zizyphus mauratiana, Carissa opaca* etc. occur on adjoining ground not liable to inundation.

(ii) *Dhond, Poona Division, Maharashtra.*—

I. *Acacia arabica**, *Azadirachta indica* (naturalised), *Ailanthus excelsa.*

II. *Pongamia pinnata, Zizyphus mauratiana.*

GENERAL NOTE.—This form grows under different soil conditions from the black soil sub-type, cf. p. 214.

SECONDARY SERAL TYPES

2S1. Secondary dry deciduous forest

DESCRIPTION.—An inferior form of the climax type marked by the poor shape and size of the trees, absence of old trees except sometimes scattered semi-cultivated or useless species, and irregular stocking. Thorny species and species unpalatable to cattle tend to predominate. Sandal is an important and often characteristic feature.

DISTRIBUTION.—Throughout the dry deciduous forests extending into the drier parts of the moist deciduous.

LOCALITY FACTORS.—As for the general group (cf. p. 190) but the forest has been subjected to more or less complete clearance at some time in the past for shifting or semi-permanent cultivation and has grown up again, usually subject to heavy use for grazing, fuel and small timber. The surface soil is commonly hard and impervious from exposure and trampling.

FLORISTICS.—

(i) *Partapgarh forests, Banswara Division, Salamgarh Range, Rajasthan.* (SAXENA).—

I. & II. *Prosopis spicigera**, *Salvadora oleoides**, *Terminalia tomentosa, Santalum album, Butea monosperma, Mitragyna parvifolia.*

III. *Lantana camara, Holarrhena antidysenterica, Nyctanthes arbor-tristis* (o).

IVa. *Cassia tora, Ocimum americanum, Xanthium strumarium, Echinops echinatus.*

IVb. *Echinops echinatus, Schima nervosum, Themeda quadrivalvis, Echinochloa colonum, Cynodon dactylon, Apluda mutica, Aristida* etc.

V. No climbers.

Note.—The top canopy is very open; sandal occurs near cultivated fields.

(ii) *Dharwar Taluka forests, Mysore.*—

I. *Salmalia malabarica*, *Buchanania lanzan*, *Grewia tiliaefolia*, *Elaeodendron glaucum*, *Schleichera oleosa*, *Lannea coromandelica*, *Semecarpus anacardium*, *Tectona grandis*.

II. *Feronia limonia*, *Aegle marmelos*, *Zizyphus xylopyrus*, *Careya arborea*, *Gardenia* spp., *Dolichandrone atrovirens*, *Santalum album**.

III. *Dodonaea viscosa**, *Carissa spinarum*, *Holarrhena antidysenterica*, *Lantana* (la).

Note.—An open park like forest in which the trees grow in groups separated by grassy glades made often well nigh impenetrable by *Lantana* brakes.

General Note.—These examples are typical and it is unnecessary to give others. *Soymida* has been quoted (VAHID) as a species colonising abandoned cultivation.

GROUP 6. TROPICAL THORN FORESTS

Sub-group 6A. Southern Tropical Thorn Forests

1. NOMENCLATURE

Madhya Pradesh	Thorn forests. *Babul bans.*
Maharashtra	Thorn forests. Thorn and scrub forests. Riverain *babul*.
Madras and Mysore	Scrub jungle. Semi desert scrub. *Acacia chundra* forest.

2. GENERAL DESCRIPTION

An open low forest in which thorny usually hardwooded species predominate, *Acacia* spp., being particularly characteristic. The trees usually have short boles and low branching crowns which rarely meet. The usual height is 6 to 9 m. There is usually a mixture of species (though relatively few in number), consociations being the exception rather than the rule. There is an ill-defined lower storey of smaller trees and large shrubs, mostly spiny and often with other xerophytic characters, extending down to low shrub growth of similar character. There is usually a thin grass growth which may appear fairly complete during the short moist season, but more or less of the soil is bare. Climbers are few, also frequently showing xerophytic adaptations.

3. DISTRIBUTION

In C. India throughout the dry peninsular tract to the lee of the W. Ghats from the extreme south up to Indore and Bhopal. It is thus important in Maharashtra, Andhra Pradesh, Mysore and Madras.

4. LOCALITY FACTORS

Temperature.—Data for a selection of representative stations is given on the next page.

Temperature (centigrade)

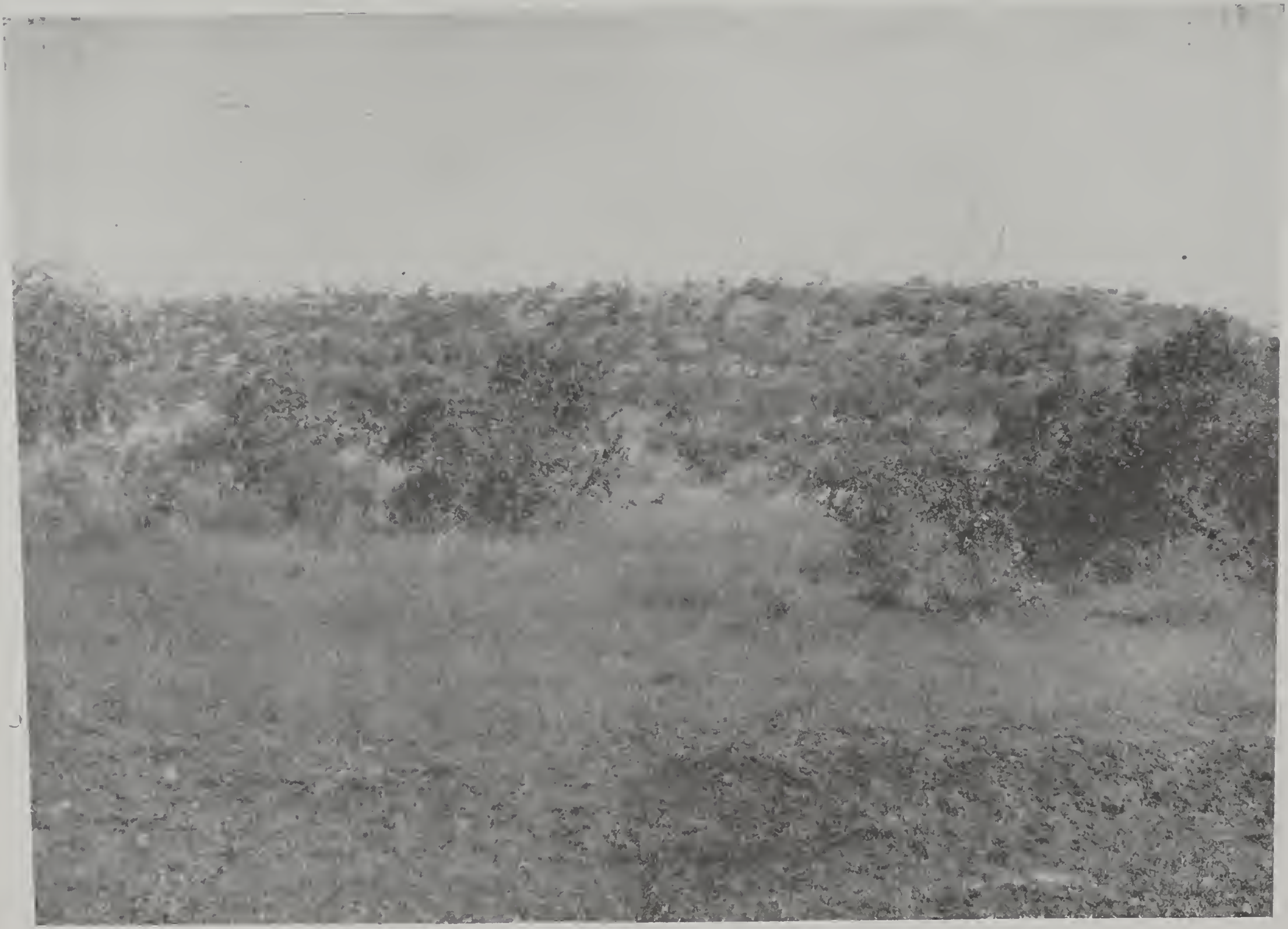
Southern Thorn Forests

Month	Maharashtra AKOLA 282 m.			Maharashtra POONA 559 m.			Maharashtra SHOLAPUR 479 m.			Andhra Pradesh BIJAPUR 594 m.			Andhra Pradesh KURNOOL 281 m.		
	Mean	Mean max.	Mean min.	Mean	Mean max.	Mean min.	Mean	Mean max.	Mean min.	Mean	Mean max.	Mean min.	Mean	Mean max.	Mean min.
January	21·4	30·1	12·7	21·0	30·3	11·7	23·0	30·8	15·2	22·9	30·1	15·7	23·9	31·3	16·4
February	23·4	32·6	14·3	22·7	32·5	12·8	25·3	33·6	17·1	25·3	32·8	17·7	26·6	34·2	18·9
March	28·0	37·1	18·9	26·3	36·1	16·5	29·0	37·3	20·7	28·7	36·1	21·2	30·4	37·8	23·1
April	32·3	40·8	23·8	29·2	38·3	20·2	31·9	39·7	24·1	30·9	38·2	23·6	32·9	39·8	26·1
May	34·9	42·3	27·4	29·8	37·1	22·4	32·7	40·4	25·0	31·2	38·7	23·6	33·8	40·3	27·2
June	31·5	37·2	25·7	27·5	31·9	23·1	28·7	35·1	22·2	27·8	33·4	22·3	30·7	31·2	25·3
July	27·8	31·7	23·8	25·1	28·1	22·1	27·1	31·8	22·3	26·0	30·3	21·6	28·6	33·1	23·9
August	27·0	30·8	23·7	24·5	27·6	21·4	26·7	31·6	21·7	25·8	30·4	21·1	28·0	32·5	23·5
September	27·4	31·9	22·8	24·9	29·2	20·5	26·6	31·5	21·7	25·9	30·8	21·1	27·8	32·2	23·3
October	26·6	33·7	19·4	25·5	31·9	19·1	26·5	32·6	30·4	26·0	31·5	30·4	27·3	32·6	22·1
November	22·9	31·1	14·7	22·6	30·3	14·7	14·0	30·8	17·1	23·4	29·8	17·1	24·9	31·1	18·8
December	20·6	29·3	11·8	30·8	29·4	12·2	22·2	29·7	14·7	21·9	29·0	14·8	23·2	30·2	16·0
M. A. T.	?	..	..	?	..	..	27·0	..	..	26·3	..	..	28·2	..	..
Annual mean maximum	34·1	..	..	31·9	..	..	33·7	..	..	32·6	..	..	34·3	..	..
Highest record	47·2	..	..	43·3	..	..	45·6	..	..	42·8	..	..	45·6	..	..
Annual mean minimum	19·9	..	..	18·0	..	..	20·3	..	..	20·0	..	..	22·0	..	..
Lowest record	2·2	..	..	1·7	..	..	6·1	..	..	6·7	..	..	6·7	..	..
No. of years	60 (to 1940)	..	.	60 (to 1940)	..	..	60	..	..	45	..	..	50	..	.

Temperature (centigrade)—concld.

Southern Thorn Forests

Month	Mysore BELLARY 449 m.			Mysore MYSORE 667 m.			Madras COIMBATORE 409 m.			Madras TUTICORIN 4 m.			Madras PAMBAN 11 m.		
	Mean	Mean max.	Mean min.	Mean	Mean max.	Mean min.	Mean	Mean max.	Mean min.	Mean	Mean max.	Mean min.	Mean	Mean max.	Mean min.
January	23·9	31·0	16·8	22·5	29·0	16·0	24·2	30·0	18·3	25·1	27·7	22·3	25·9	28·1	23·6
February	26·2	33·4	18·9	24·8	31·6	17·9	25·9	32·7	19·2	25·7	28·2	23·1	26·6	29·3	23·9
March	29·9	37·5	22·4	27·1	34·3	19·8	28·2	35·2	21·2	27·1	29·6	24·7	28·2	31·4	24·8
April	30·4	33·5	25·2	28·1	34·8	21·3	28·2	33·2	23·1	31·4	37·1	25·7	29·7	32·8	26·5
May	32·2	38·9	25·4	27·2	33·3	21·1	28·9	34·7	23·1	30·5	34·5	26·4	30·2	33·2	27·3
June	29·6	34·8	24·4	24·7	29·4	20·1	26·9	31·6	22·2	31·0	35·4	26·6	29·6	32·3	26·8
July	28·2	32·6	23·9	23·7	27·9	19·6	26·1	30·4	21·7	30·3	34·1	26·6	29·1	31·8	36·3
August	27·9	32·5	23·3	23·8	28·3	19·3	26·2	30·8	21·7	30·3	34·2	26·4	28·9	31·7	26·0
September	27·7	32·5	22·8	24·1	29·0	19·2	26·6	31·5	21·6	29·3	29·9	25·8	28·9	31·8	25·9
October	27·0	32·1	21·8	24·2	29·0	19·4	26·2	30·9	21·5	29·1	32·8	25·3	28·2	31·1	25·4
November	24·8	30·6	19·0	23·0	27·9	18·0	25·1	29·7	20·6	26·7	29·7	23·6	27·1	29·5	24·6
December	23·2	29·8	16·6	21·9	27·7	16·2	24·0	29·1	18·9	24·4	27·4	21·5	25·9	28·1	23·8
M. A. T.	?	..	..	24·6	..	..	?	..	..	28·4	..	..	28·2	..	..
Annual mean maximum	33·3	..	..	30·2	..	..	31·8	..	..	31·9	..	..	30·9	..	..
Highest record	43·9	..	..	38·3	..	..	40·0	..	..	?	..	..	37·2	..	..
Annual mean minimum	22·1	..	..	19·0	..	..	21·1	..	..	24·8	..	..	25·4	..	..
Lowest record	10·6	..	..	10·6	..	..	11·7	..	..	?	..	..	19·4	..	..
No. of years	60 (to 1940)	..	..	45	..	..	60 (to 1940)	..	..	upto 1955	..	..	50	..	..



SOUTHERN THORN FOREST

Open *Acacia* spp., *Zizyphus*, *Hardwickia*, *Diospyros* etc. on dry shallow soil. Chirodi, Amraoti Division, Maharashtra.

H. G. Champion

The mean annual temperature is not appreciably higher than for the other tropical types, being typically 25·5° C. A few places such as Bellary are hotter and Bangalore with its extra 300 m. of altitude a few degrees cooler. The hottest month is May when the monthly mean is usually 29·5 to 32° C. whilst the mean maximum is usually over 41°C. The January means are a little over 21°C. with mean minimum varying from as low as 4·4° C. (Akola) up to 13·3°C (Coimbatore) some 10° latitude further south.

Rainfall and Humidity.—The rainfall data for the same localities with one additional station are given on the next page.

Mysore exemplifies conditions verging on those characteristic of the dry deciduous. Although Akola receives a longer rainfall, the humidity is lower. The much greater humidity of the southern-most stations will be noted, northern stations being well below 60. There is typically practically no rain from November to April inclusive and very little in May, at least two-thirds and usually a larger proportion of the precipitation occurring as monsoon rain in June to October. Coimbatore has a different distribution with October and November as the only months with a fall over 100 mm., very little rain being derived from the S. W. monsoon.

Soil.—The type is met with on a wide range of geological formations and rocks. The soil is almost always shallow and dry, though it may be of fair depth if sandy. The type also predominates on the black cotton soil of Berar and elsewhere, and with much higher rainfall on hard laterite soil. In many localities the soil is very alkaline. Most of the forest is on flat ground or low undulating hills and plateaux.

5. GENERAL FLORISTICS

The genus *Acacia* with a number of species and several other allied genera, is characteristic above all others. Fleshy *Euphorbias* are generally present and may form a conspicuous constituent of the vegetation, and *Capparis* is also a typical genus, *Opuntia* has become naturalised over wide tracts of this type, but is not indigenous.

6. SUBDIVISIONS

The thorn forest of the Carnatic in the South-East differs significantly in composition etc., from the rest. A general scrub form and another in which *Euphorbia* predominates are also differentiated as degradation stages. Edaphic influences are probably involved in the formation of the *Euphorbia* type.

C1—*Southern thorn forest.*

C2—*Carnatic umbrella thorn forest.*

DS1—*Southern thorn scrub.*

DS2—*Southern Euphorbia scrub.*

C1. Southern thorn forest

DESCRIPTION.—This is the central form of the type as described on p. 226. *Acacia catechu* in one of its forms (*A. catechu* SS, *A. catechuoides*, *A. chundra*) is almost invariably present and though not necessarily predominating, is very often so. With

Rainfall (millimetres)

Southern Thorn Forests

Month	Maharashtra	Maharashtra	Maharashtra	Maharashtra	Andhra Pradesh	Andhra Pradesh	Mysore	Mysore	Madras	Madras	Madras	Madras	Madras
	AKOLA	POONA	SHOLAPUR	DHOND	BIJAPU	KURNOOL	BELLARY	MYSORE	COIMBATORE	TUTICORIN	RAMNAD	PAMBAN	TIRUNELVELI
	282 m.	559 m.	479 m.	514 m.	594 m.	281 m.	449 m.	667 m.	409 m.	4 m.	6 m.	11 m.	39 m.
January	9	2	4	3	5	4	3	4	16	26	39	65	54
February	8	2	3	2	2	7	5	6	9	25	23	22	27
March	9	2	6	10	5	5	5	13	13	29	23	18	42
April	5	15	14	21	22	17	21	58	40	43	48	47	62
May	10	27	23	87	29	27	48	142	63	21	30	25	37
June	141	114	103	63	77	74	43	63	39	5	10	4	9
July	249	167	106	43	60	112	41	68	42	4	20	12	10
August	161	90	109	133	61	114	61	84	31	6	41	15	20
September	147	134	193	61	141	151	124	126	40	16	51	29	36
October	46	90	77	30	73	81	106	149	160	141	199	217	186
November	19	27	34	6	32	30	50	70	102	183	242	298	196
December	14	4	10	4	6	5	3	10	35	80	125	193	130
Total for year (M.A.R.)	817	673	691	461	513	630	518	792	590	583	850	943	810
No. of rainy days	45	47	41	31	33	45	34	57	45	29	41	48	45
No. of months less than 50 mm.	8	7	7	8	7	7	8	4	9	9	8	8	7
M. A. Humidity	49%	58%	47%	?	52%	52	50%	63%	67%	69%	?	81%	?
No. of years	?	?	60	49	45	50	?	45	?	?	71	50	30

it are associated several other *Acacias* and allied thorny *Mimosae* and usually *Zizyphus* whilst stunted specimens of the trees of the dry deciduous forest occur scattered in varying numbers throughout, notably *Anogeissus latifolia*, *Soymida* and the like. Patches of the fleshy *Euphorbias* are not infrequently met with.

DISTRIBUTION.—The most widely spread form occurring throughout the tract occupied by thorn forests except on the south coastal tracts where it is replaced by C2.

LOCALITY FACTORS.—Those of the Sub-group, *see* pp. 226-229.

ILLUSTRATION.—Plate 55.

FLORISTICS.—

(i) *Lontek, Amraoti Division, Maharashtra.*—

I. *Acacia leucophloea** (a), *A. arabica** (f), *Balanites aegyptiaca* (f). *Cordia dichotoma* (6 m. high).

II. *Dichrostachys cinerea** (a), *Phoenix* (o), *Gymnosporia* sp. (o), *Zizyphus mauratiana* (f).

III. *Mimosa hamata** (a), *Calotropis procera* (o).

IVb. *Heteropogon contortus* and other grasses forming a thin cover.

V. *Pergularia daemia* (a), *Cardiospermum* (f) etc.

NOTE.—Total cover about 0.5 with bare *kankar* patches heavily grazed.

(ii) *Dhond, Poona Division, Maharashtra.*—

I. *Acacia arabica*, *A. latronum*, *Capparis decidua*, *C. divaricata*, *Balanites aegyptiaca*, *Prosopis spicigera*, *Azadirachta indica*, (*Zizyphus mauratiana*, *Dichrostachys*).

II. *Mimosa hamata**, *Cassia auriculata*.

IVb. *Aristida redacta*, *A. royleana*, *Heteropogon contortus**.

(iii) *Sholapur Division, Maharashtra.*—

I. & II. *Acacia catechu**, *A. leucophloea**, *Anogeissus latifolia*, *Azadirachta indica*, *Bauhinia racemosa*, *Flacourtia indica*, *Randia*, *Zizyphus mauratiana*, *Z. vulgaris*, *Gardenia gummifera*, *Dolichandrone falcata*, *Santalum album*, *Strychnos potatorum*, *Grewia tiliaefolia*, *Ixora arborea*.

III. *Mimosa hamata*, *Bridelia stipularis*, *Cassia auriculata*.

(iv) *Ellora, Andhra Pradesh.*—

*Acacia catechu**, *A. leucophloea**, *Ailanthus excelsa*, *Azadirachta indica*, *Dolichandrone falcata*, *Gymnosporia spinosa*, *Ixora arborea*, *Carissa carandas*, *C. spinarum*, *Euphorbia*.

(v) *Panapakam, Chittoor Division, Andhra Pradesh.*—

I. *Albizzia amara** *Acacia chundra**, *Azadirachta indica*, *Cassia fistula*, *Albizzia odoratissima*. *Randia dumetorum*, *Anogeissus latifolia*.

III. *Carissa carandas, Canthium dicoccum, Strychnos* sp., *Dodonaea viscosa, Cassia auriculata.*

IVb. *Aristida*, Heteropogon contortus.*

V. *Zizyphus oenoplia.*

(vi) *Dharwar-Bijapur Division, Mysore.—*

I. *Acacia catechu*, A. leucophloea*, A. arabica*, Aegle marmelos, Chloroxylon swietenia, Euphorbia nivulia, Ficus asperrima, Flacourtia indica, Ixora arborea, Strychnos potatorum, Santalum album.*

II. *Carissa* spp., *Cassia auriculata, Dodonaea viscosa, Opuntia* (nat.)

III. *Lantana* (nat.).

V. *Zizyphus oenoplia.*

(vii) *C. Salem, Madras.—*

I. & II. *Chloroxylon swietenia*, Albizzia amara, Acacia chundra*, A. ferruginaea*, Azadirachta indica, Canthium dicoccum, Erythroxylon monogynum, Zizyphus mauratiana, Z. xylopyrus, Cleistanthus collinus, Dichrostachys cinerea, Atalantia monophylla.*

ECOLOGICAL STATUS.—

SCHIMPER was of the opinion that thorn woodland is often the effect of excessive cutting and browsing and so often not a climatic formation. In Madhya Pradesh it is found that forest protection is permitting teak to displace the less exacting species such as *Sterculia urens* and *Diospyros tomentosa* (VAHID). The same applies to large parts of Rajasthan and Gujarat and no doubt elsewhere too.

C2. Carnatic umbrella thorn forest

DESCRIPTION.—As open thorny forest in which *Acacia planifrons* with its umbrella shaped crown is conspicuous with thickets of other species of *Acacia* and many of the xerophytic evergreen species of the dry evergreen forest. The resemblance to African thorn (savannah) forest is marked.

DISTRIBUTION.—Madurai, Tirunelveli, Ramnad, Rameshwaram, Dindigal, etc. in S. Madras.

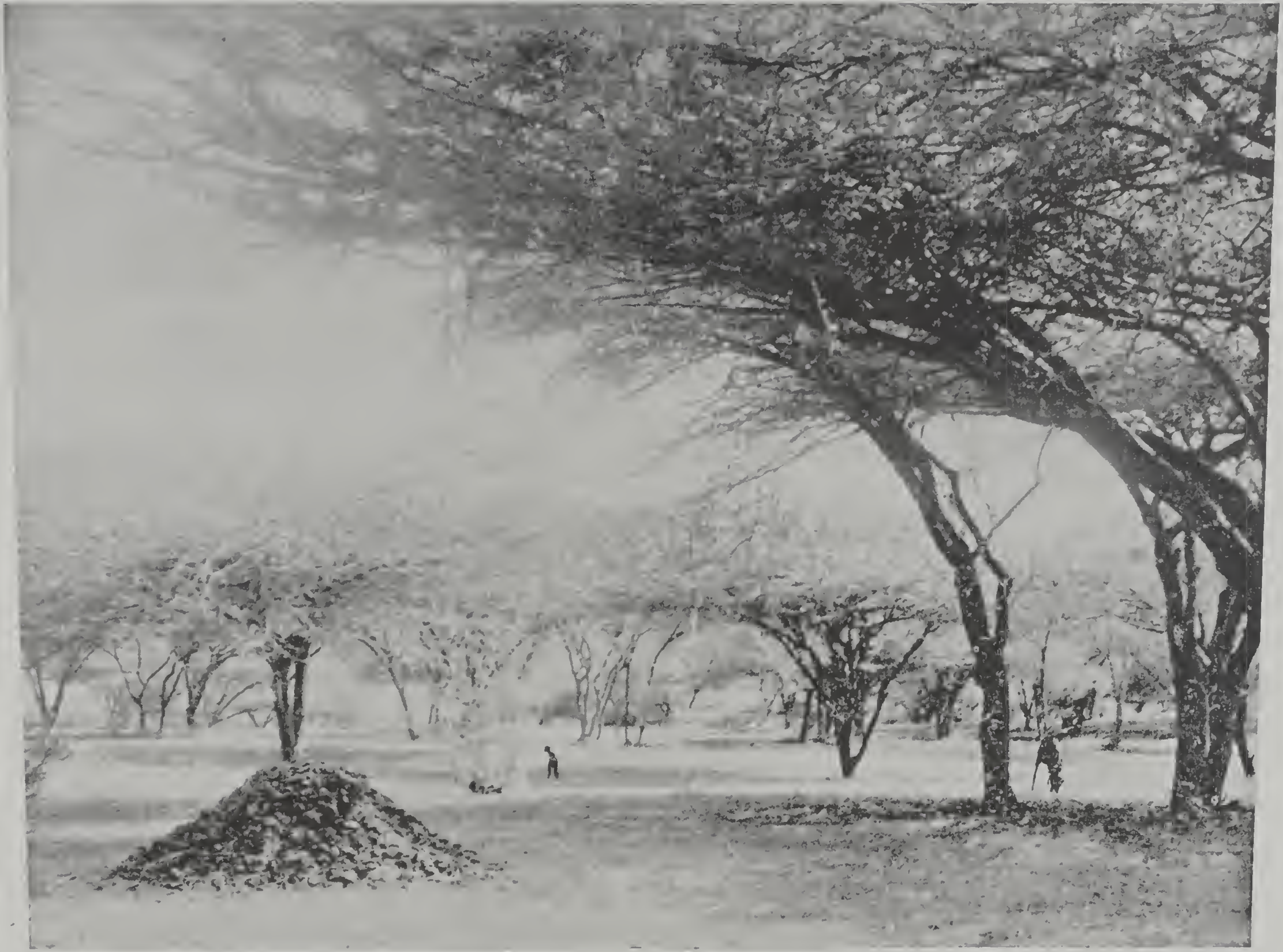
LOCALITY FACTORS.—The climate is represented in the table on p. 230 by Tuticorin, Ramnad and Pamban. It is marked by the low rainfall received from the S. W. monsoon in June-September, the bulk of the rainfall coming in October-November. Dry edaphic conditons as at Dindigal or on coastal sand dunes at Pamban, Rameshwaram etc. also result in the development of this type.

ILLUSTRATION.—Plate 56.

FLORISTICS.—

I. *Acacia planifrons*, Albizzia amara.*

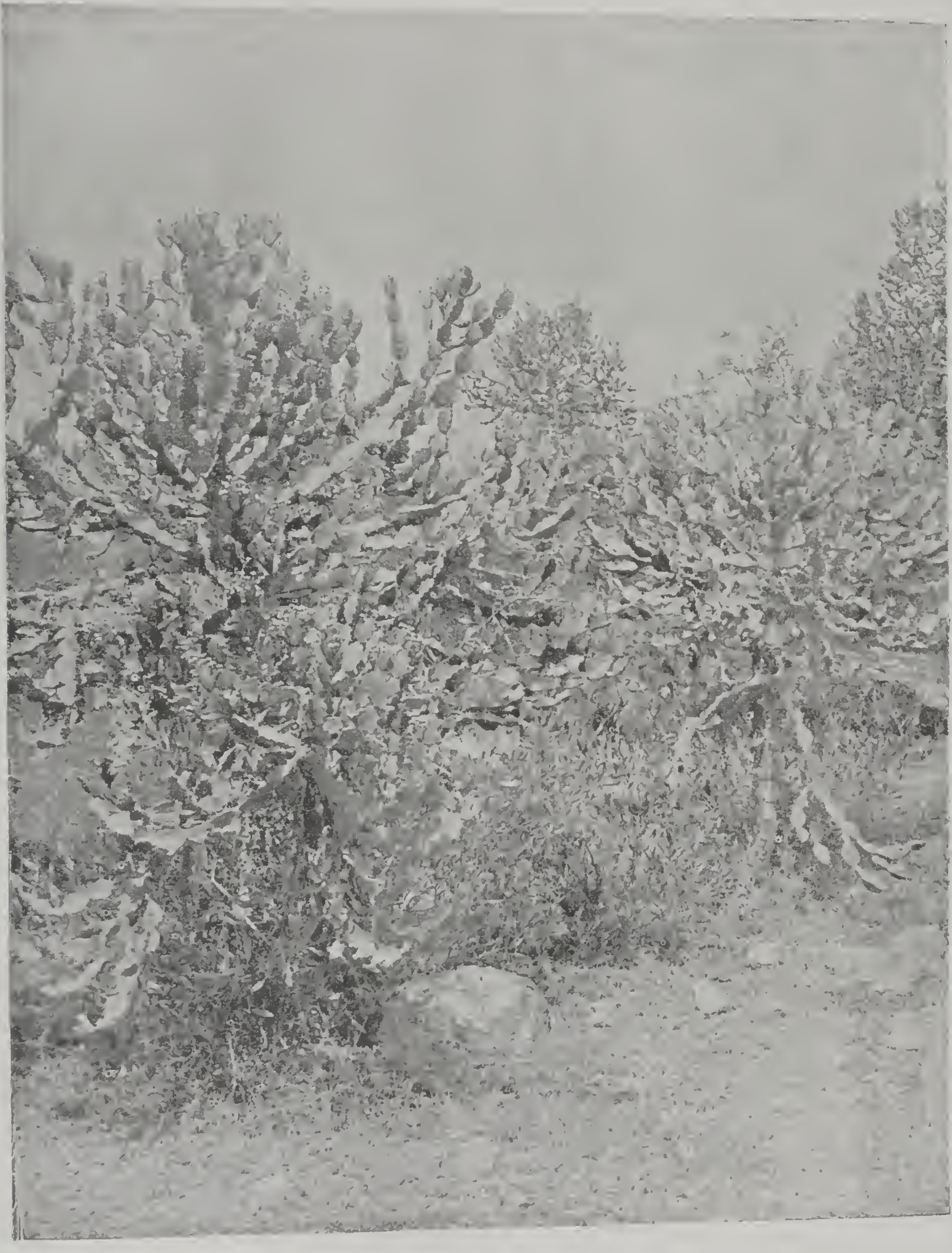
II. *Acacia latronum*, Dichrostachys cinerea, Chloroxylon swietenia.*



CARNATIC UMBRELLA THORN FOREST

Pure *Acacia planifrons* association, Kanyakumari, Madras.

H. G. Champion



SOUTHERN EUPHORBIA SCRUB

Euphorbia trigona association with *Dodonea viscosa* and *Cassia auriculata*.
Krishnagiri, Madras.

H. G. Champion

III. Thorny shrubs.

V. *Dalbergia spinosa.*

DS1. Southern thorn scrub

Degradation as a result of the usual maltreatment results in the formation of close almost impenetrable thorny thickets, 4—6 m. high, not much different in composition from the undergrowth characteristic of the prevailing climax type, in which the few surviving trees stand out here and there. Spiny climbers are common.

Further degradation may result in sparse thickets, 2-4 m. high in which grasses are more abundant. The floristic composition remains essentially unaltered.

FLORISTICS.—

Plains Region, Madras.—

I. *Albizzia amara, Azadirachta indica, Chloroxylon swietenia, Wrightia tinctoria* (very few and scattered).

III. *Zizyphus xylopyrus*, Dichrostachys cinerea*, Capparis divaricata, Securinega leucopyrus, Randia dumetorum, Canthium dicoccum, Flacourtia indica.*

V. *Pterolobium indicum, Acacia pennata.*

DS2. Southern Euphorbia scrub

DESCRIPTION.—A very open formation in which fleshy *Euphorbias* are the most important constituent. The thorny *Acacias* and their associates also occur but are more than usually stunted, and form widely spaced low rounded bushes. Much of the soil is bare but there is usually a thin cover of wiry grasses.

DISTRIBUTION.—Scattered throughout the type usually on the shallowest and poorest sites.

LOCALITY FACTORS.—Climate that of the type. Soil shallow and rocky, or alkaline.

ILLUSTRATION.—Plate 57.

FLORISTICS.—

(i) *Krishnagiri, Madras* —

I. *Euphorbia tirucalli*, Capparis**, sp.

II. *Dodonaea viscosa, Cassia auriculata.*

(ii) *Dry Plains Region, Madras.*—

I. *Euphorbia antiquorum*, E. tirucalli*.*

II. *Dodonaea viscosa, Cassia auriculata, Calotropis gigantea, Barleria buxifolia, Opuntia dillenii.*

IVb. *Aristida hystrix, A. depressa, Cymbopogon coloratus* (o).

General Note.—This type is very widespread and represents both extreme edaphic conditions (badly eroded, very rocky, with soil in crevices only if the slopes are steep) as well as the ultimate stage in degradation. The scattered small consociations of *Euphorbia* sometimes found in dry deciduous forests should perhaps not be included here.

Sub-group 6B. Northern Tropical Thorn Forests

1. NOMENCLATURE

Punjab	*Rakh* forests. Plains forests and scrub.
Uttar Pradesh	Ravine scrub. *Usar* plains vegetation. Dry thorn forests (KANJILAL for Bundelkhand).

2. GENERAL DESCRIPTION

Generally similar to the southern form but exhibiting all stages of diminution of vegetation to true climatic desert, *Acacias* and their allies remain characteristic but are perhaps less predominant whilst fleshy *Euphorbias* are only met with in extensive consociations in Rajasthan and Gujarat. There is much less admixture of trees of the dry deciduous forest, probably owing to the wide extent of the tract of low rainfall. The dominants vary from 4.5 to 10 m. in height and tend to be collected in clumps leaving bare ground between. Regeneration by rootsuckers common (notably in *Prosopis* and *Capparis*). Climbers are relatively numerous and also usually exhibit xerophytic adaptations. The woody growth is of all sizes from the trees down to dwarf shrubs, with no differentiation into storeys. The perennial grasses also grow in clumps and tussocks (notably *Lasiurus hirsutus*). There is a thin growth of annual grass after rains.

3. DISTRIBUTION

The type spreads over the semi-arid regions of U. P., M. P. and the major portion of semi-arid and arid regions of Punjab, Rajputana and northern Gujarat including Saurashtra and Kutch.

4. LOCALITY FACTORS

Temperature.—Data for ten representative stations are given in the following table.

The mean annual temperature is only a degree or two lower than for the southern variation, typically 25° C. The hottest month is June as the S. W. monsoon is feeble and the annual mean max. is practically always above 31° C, definitely higher than in the south except in the coastal regions of Gujarat. The winter temperatures are markedly lower, the annual mean minimum being 15° C. or less, in fact the lowest temperature may fall to below freezing point. The highest temperature generally exceeds 45°C.

These figures demonstrate that on several grounds, particularly the low winter temperature, the type could be included in the subtropical zone, but the affinites are so definitely tropical that separation is uncalled for. The vegetation in fact provides the true picture of the climatic regime.

Temperature (centigrade)

Northern Thorn Forests

Month	Delhi DELHI 218 m.			Uttar Pradesh AGRA 169 m.			Rajasthan SRI GANGA-NAGAR 177 m.			Rajasthan BIKANER 224 m.			Rajasthan JODHPUR 224 m.		
	Mean	Mean max.	Mean min.	Mean	Mean max.	Mean min.	Mean	Mean max.	Mean min.	Mean	Mean max.	Mean min.	Mean	Mean max.	Mean min.
January	13·8	21·4	6·3	14·7	22·6	6·8	11·7	19·9	3·4	15·2	22·1	8·3	16·9	24·6	9·2
February	16·7	23·7	9·6	17·1	25·2	9·0	15·4	23·1	7·6	17·9	24·9	10·9	19·2	27·0	11·4
March	21·7	29·4	13·9	23·1	31·6	14·6	19·8	28·3	11·2	24·2	31·5	16·9	24·4	32·5	16·4
April	27·9	35·9	19·8	29·3	37·8	20·9	25·4	34·2	16·7	30·2	37·5	22·9	29·5	37·4	21·6
May	32·2	40·4	26·0	33·4	41·2	25·7	33·0	42·1	23·9	34·7	41·7	27·7	33·6	40·8	26·3
June	33·6	39·1	28·1	34·3	40·0	28·6	34·5	41·6	27·4	35·6	41·7	29·4	33·9	39·8	27·9
July	31·2	35·2	27·2	30·6	34·3	26·9	33·5	38·9	28·1	33·3	38·4	28·2	31·4	36·1	26·8
August	29·8	33·9	25·8	29·6	33·0	26·1	32·3	37·7	26·9	31·7	36·4	26·9	29·1	33·2	25·0
September	29·2	34·2	24·2	29·2	33·8	24·6	30·6	37·8	23·4	31·2	36·7	25·6	29·2	34·6	23·8
October	25·8	33·6	17·9	26·1	33·8	18·4	25·2	35·1	15·4	28·4	35·4	21·4	26·9	35·3	18·6
November	19·7	28·4	11·0	20·1	29·1	11·1	19·0	29·2	9·3	22·1	29·8	14·3	22·1	30·9	13·0
December	15·2	23·2	7·2	16·1	24·1	7·9	13·8	23·1	4·4	16·7	24·1	9·3	18·2	26·1	10·3
Annual mean	24·8	..	..	25·3	..	..	24·6	..	..	26·8	..	..	26·2	..	..
Annual mean maximum	31·6	..	..	32·2	..	..	32·7	..	..	33·3	..	..	33·2	..	..
Highest record	46·1	..	..	48·3	..	..	50·0	..	..	49·4	..	..	48·9	..	..
Annual mean minimum	18·1	..	..	18·4	..	..	16·4	..	..	20·2	..	..	19·2	..	..
Lowest record	—0·6	..	..	—2·2	..	..	2·2	..	..	—1·1	..	—	—2·2	..	..
No. of years	60	..	..	?	..	..	7	..	..	60	..	..	40	..	..

Temperature (centigrade)—concld.

Northern Thorn Forests

Month	Rajasthan JAIPUR 436 m.			Rajasthan AJMER 385 m.			Gujarat BHUJ 105 m.			Gujarat DWARKA 11 m.			Gujarat RAJKOT 132 m.		
	Mean	Mean max.	Mean min.	Mean	Mean max.	Mean min.	Mean	Mean max.	Mean min.	Mean	Mean max.	Mean min.	Mean	Mean max.	Mean min.
January	15·6	22·9	8·2	15·1	22·6	7·6	18·8	26·3	11·3	20·4	25·5	15·3	25·1	28·5	10·6
February	17·7	25·0	10·3	17·5	25·0	9·9	21·2	28·7	13·6	21·6	25·8	17·3	21·3	30·3	12·4
March	23·1	31·3	14·9	23·3	30·9	15·7	25·9	33·8	17·9	24·7	27·9	21·4	25·9	35·1	16·7
April	28·6	36·8	20·4	29·1	36·3	21·4	29·8	37·7	21·8	27·1	29·5	24·7	29·8	38·7	20·8
May	32·9	40·9	24·9	33·1	39·4	26·8	31·8	38·1	25·4	29·1	31·1	27·0	32·2	40·5	24·0
June	33·2	39·5	26·9	32·9	38·0	27·7	31·4	36·3	26·5	29·9	31·8	28·0	31·6	37·4	25·7
July	30·1	34·6	25·7	29·5	33·2	25·8	29·2	32·7	25·6	28·7	30·4	27·1	28·8	32·9	24·7
August	28·6	32·7	24·4	27·7	30·9	24·4	28·0	31·3	24·7	27·6	29·3	25·9	27·7	31·6	23·8
September	28·3	33·9	22·7	27·9	32·2	23·6	28·5	32·2	24·8	27·5	29·6	25·4	27·9	33·2	22·6
October	26·2	34·5	17·9	25·6	33·1	18·1	28·5	35·6	21·4	27·4	30·7	24·2	27·9	35·4	20·4
November	20·9	29·7	12·1	20·1	28·7	11·5	24·4	32·1	16·7	25·5	30·6	20·4	24·4	32·8	15·9
December	16·7	24·7	8·7	16·1	24·1	8·1	20·1	27·7	12·4	22·0	27·3	16·6	20·7	29·5	11·9
Annual mean	25·2	..	..	24·8	..	..	26·4	..	..	25·9	..	..	26·9	..	..
Annual mean maximum	32·2	..	..	31·2	..	..	32·8	..	..	29·1	..	..	33·8	..	..
Highest record	47·8	..	..	45·6	..	..	47·8	..	..	42·2	..	..	47·8	..	..
Annual mean minimum	18·1	..	..	18·4	..	..	20·1	..	..	22·8	..	..	19·1	..	..
Lowest record	—2·2	..	..	—2·8	..	..	1·1	..	..	6·1	..	..	—0·6	..	..
No. of years	?	..	..	60	..	..	60	..	..	40	..	..	60	..	..

Rainfall and humidity.—Rainfall is from 760 mm. down to under 250 mm. and is mostly derived from the S. W. monsoon in July to August though in the north an appreciable proportion falls in the winter months. Data are given for the same stations as selected to illustrate temperature conditions, with the addition of Etawah in S. Uttar Pradesh.

Many stations like Delhi, Agra, Etawah, Jaipur, Ajmer and Rajkot are favourab'y situated enough to have local patches of dry deciduous forest such as *Anogeissus pendula* forests.

The mean humidity of the year is typically about 46 rather less than the southern type in accordance with the more pronouncedly continental position.

The big variation from year to year is undoubtedly important, thus a mean rainfall of 200 mm. may include a range of 50-600 mm. in a decade (WAHEED KHAN).

Soil and topography.—Mostly on flat alluvial or aeolian soils, but extending over low hilly country (Aravalli Hills and Saurashtra) and characteristic of eroded ravine lands as in Etawah. Local variations of soil, above all those due to the concentration of salts which is a consequence of the climatic conditions, are most marked in their effect on the vegetation. Patches of highly saline soil (*kallar*, *usar*), the salts being usually chloride, sulphate, carbonate of sodium, are usually bare of vegetation. Concretionary limestone (*kankar*) also occurs in places. The saline soils are usually impervious and such rain as falls largely evaporates before it soaks in. Blown sand is met with in many places and supports a rather different vegetation.

5. GENERAL FLORISTICS

Thorny *Mimosae* occur throughout with a number of species of which *Prosopis spicigera* is perhaps most general. The genus *Acacia* is also very widespread. *Capparis* is usually present and *Capparis decidua* is often one of the most conspicuous trees. *Asclepiads* are well represented among the shrubs, *Calotropis* being particularly frequently seen. The fleshy *Suaeda* and *Salsola* (*Chenopodiaceae*) are common on saline soils, and *Calligonum polygonoides* (*Polygonaceae*) on sandy soils. The most characteristic grasses are *Lasiurus hirsutus* and *Panicum turgidum* on aeolian sands, *Sporobolus marginatus* on saline soils, and *Cenchrus* spp. throughout the tract.

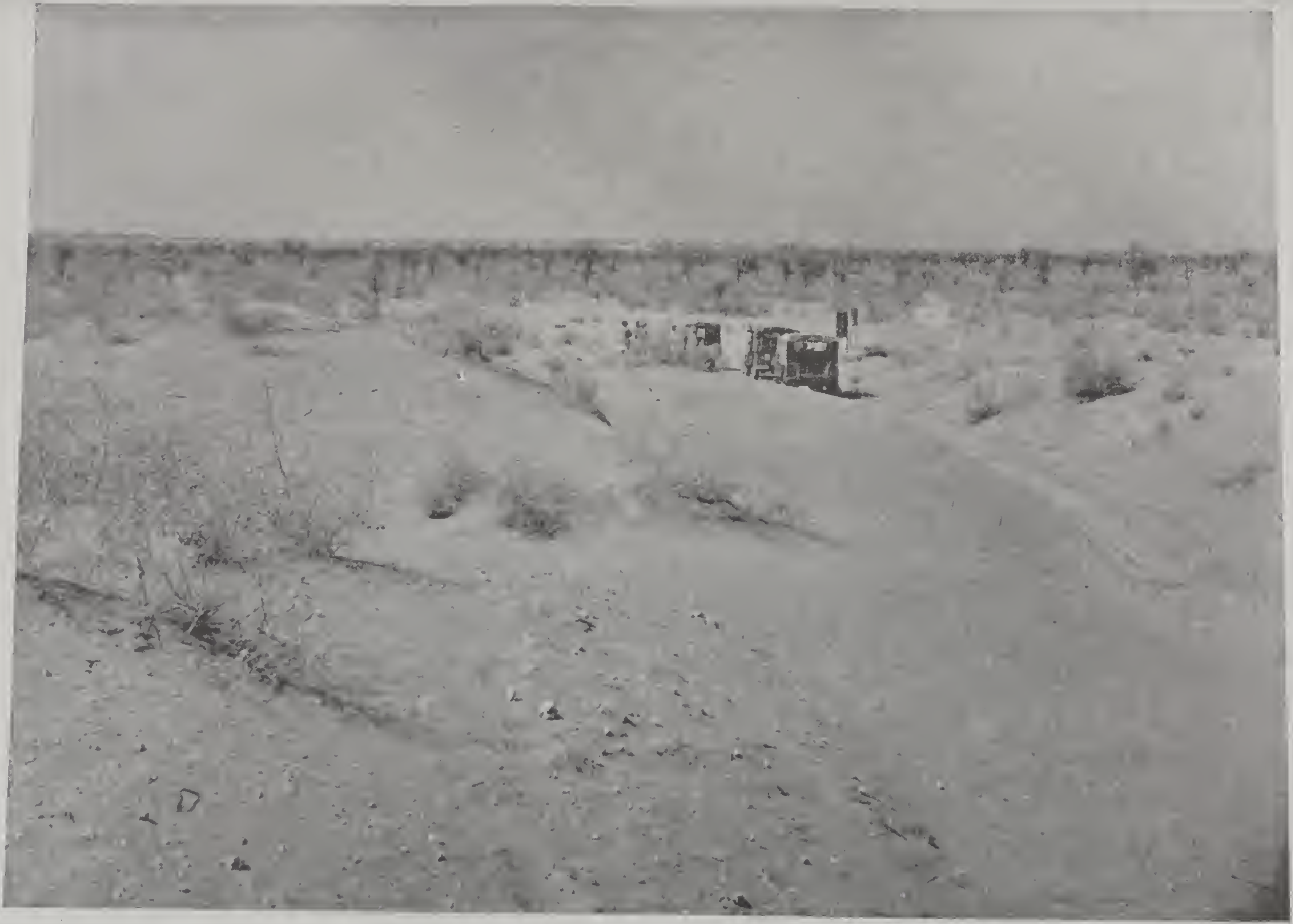
6. SUBDIVISIONS

There appear to be significant differences between the mixed thorn forests bordering the deserts of the West, and those of the drier tracts of N. C. India in which *Acacias* are more predominant. The vegetation of the saline flats bordering the Rann of Kutch which are seasonally inundated by the sea, is characteristic inasmuch as *Prosopis juliflora*, introduced in the last decades of the XIX Century is spreading naturally mainly through the agency of the Kathiawar wild ass (*Equus onager*) and forming a characteristic facies. Plantations of this species, where nothing else would grow, are hastening the natural process, through added seed dispersal. Scrub growths often including thorny bushes and succulent *Euphorbias* may be due to climatic, soil or biotic factors, but are best looked upon as degradation stages.

Rainfall (millimetres)

Northern Thorn Forests

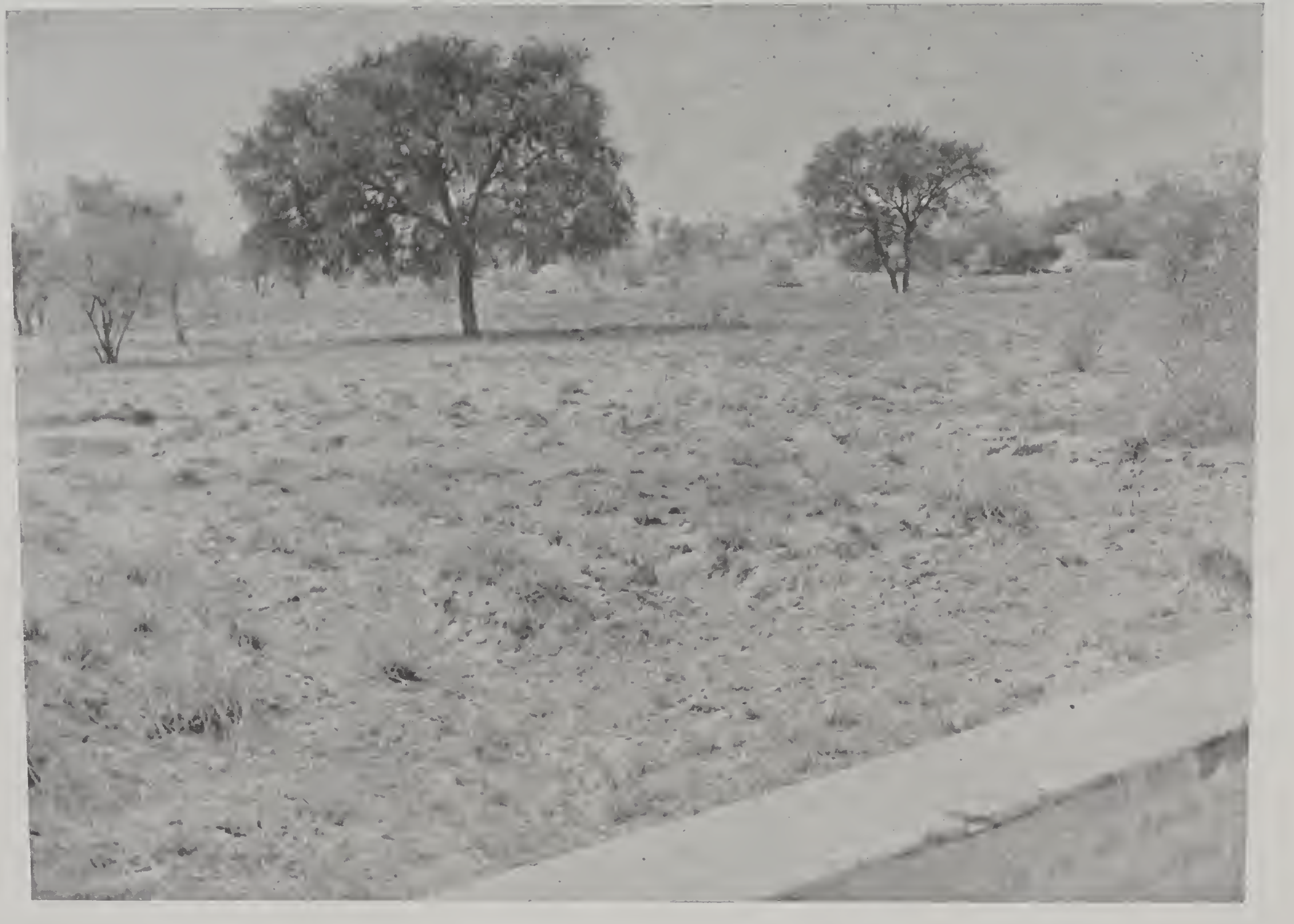
Month	Delhi DELHI 218 m.	U.P. AGRA 169 m.	U.P. ETA-WAH	Rajasthan SRI GANGANAGAR 177 m.	Rajasthan BIKANER 224 m.	Rajasthan JODHPUR 224 m.	Rajasthan JAIPUR 436 m.	Rajasthan AJMER 385 m.	Gujarat BHUJ 105 m.	Gujarat DWARKA 11 m.	Gujarat RAJKOT 132 m.
January	25	13	13	7	7	4	11	9	2	3	1
February	21	13	10	11	7	6	8	7	4	6	2
March	13	8	8	5	6	3	9	6	3	3	2
April	8	5	5	5	5	3	4	4	2	1	1
May	13	10	9	6	15	10	15	16	7	1	13
June	77	62	63	31	31	36	57	62	35	51	104
July	179	217	234	68	85	101	197	163	161	177	271
August	184	206	247	71	91	123	205	172	74	66	130
September	123	116	134	7	33	61	82	69	46	37	85
October	10	18	24	2	5	8	12	10	8	6	15
November	3	4	4	0	1	3	4	5	2	2	6
December	11	8	8	5	5	3	8	7	2	2	2
Total	667	679	758	218	291	361	610	528	346	354	630
No. of rainy days	36	37	38	15	19	20	36	30	16	16	30
No. of months with less than 50 mm.	8	8	8	10	10	9	8	8	10	9	8
M. A. Humidity	48	46	77	47	41	41	43	45	50	73	50
No. of years	?	?	?	15	60	50	?	?	60	40	60



DESERT THORN FOREST

A view of scattered *Prosopis spicigera* thorn forest in the background with desert dune vegetation (*Calligonum*, *Crotalaria* etc.) in the foreground. Joharbir, Bikaner Division, Rajasthan.

S.K. Seth



DESERT THORN FOREST

Protected reserve of Bikaner Maharajah showing climax type forest. *Tecomella* prominent, with *Acacia leucophloea* etc.
Bikaner Division, Rajasthan. *S. K. Seth*

The following types are recognised:

C1—Desert thorn forest.
C2—Ravine thorn forest.
C3—Rann thorn forest.
DS1—Zizyphus scrub.
DS2—Tropical Euphorbia scrub.

C1. Desert thorn forest

DESCRIPTION.—That of the sub-group (cf. p. 234) but towards the poorer end, with very open crops of scattered trees. Locally, consociations of certain species are prominent, notably *Acacia senegal* and *Prosopis spicigera.*

DISTRIBUTION.—In Punjab, Rajasthan and Gujarat.

LOCALITY FACTORS.—The country is flat to undulating, with low hillocks or hills. The soils are partly *in situ* but usually fluvial or aeolian deposits in various stages of consolidation. On riverain strips and shifting sand different types are developed.

ILLUSTRATIONS.—Plates 58 and 59.

FLORISTICS.—

(i) *General*—

BLATTER and HALLBERG have described the desert flora in considerable detail, illustrating it with 30 plates of photographs (cf. Pl. XXVIII and XXX).

(ii) *Joharbir, Bikaner, Rajasthan.*—

I. II. & III. *Prosopis spicigera*, Salvadora oleoides*, Calotropis gigantea, Zizyphus nummularia, Tephrosia purpurea (Calligonum polygonoides, Leptadenia pyrotechnica, Crotalaria burhia, Aerva javanica).*

IVb. *Cenchrus barbatus, Lasiurus hirsutus, Cymbopogon jwarancusa, Eleusine compressa, Aristida* spp., *Dactyloctenium scindicum.*

NOTE.—This forest is situated at the extreme end of the range on unstable sand. The crop is extremely open with a few scattered plants here and there. The species given within brackets are typical of dune vegetation. Affinites with Type 6/1S1 (Desert dune scrub) may be noted.

(iii) *Bassi, Jaipur Division, Rajasthan* (old consolidated dune sand)—

I. *Acacia senegal*, A. leucophloea*, Prosopis spicigera*, Holoptelea integrifolia, Azadirachta indica, Flacourtia indica, Balanites aegyptiaca, Tecomella undulata* (o), *Gymnosporia spinosa* (o), *Butea monosperma* (o), *Hesperethusa crenulata* (o), *Euphorbia nivulia* (o).

II. & III. *Acacia jacquemontii, Grewia pilosa, Capparis zeylanica, Calotropis procera, Zizyphus nummularia, Tephrosia purpurea.*

IVa. *Sericostoma pauciflorum*, *Crotalaria burhia.*

IVb. *Aristida* spp., *Eragrostis* spp., *Erianthus munja*, *Heteropogon contortus.*

(iv) *Kutch, Saurashtra, Gujarat.*—

I. *Acacia senegal**, *A. leucophloea**, *Cordia rothii*, *Azadirachta indica.*

II. & III. *Euphorbia neriifolia*, *E. nivulia*, *Balanites aegyptiaca*, *Salvadora*, *Commiphora mukul*, *Capparis* spp., *Grewia tenax*, *G. villosa*, *Premna integrifolia.*

IVa. *Barleria prionitis*, *Peristrophe bicalyculata*, *Justicia heterocarpa*, *J. diffusa.*

IVb. *Aristida depressa*, *Apluda mutica.*

V. *Tragia.*

(v) *Sasan, Saurashtra, Gujarat.*—

*Acacia planifrons** (almost pure); *A. arabica**, *A. catechu**, *Balanites aegyptiaca*, *Zizyphus* spp. (all occasional).

C2. Ravine thorn forest

DESCRIPTION.—This type is very like its counterpart, the southern *Acacia* thorn forest, consisting of a mixture of small thorny trees in which *Acacia* is conspicuous, standing fairly close together where not subjected to maltreatment, with a more or less complete grass cover between.

DISTRIBUTION.—Northern India wherever rainfall is between 500 and 1,000 mm. The ravine country of the Chambal drainage is representative although the type is met with on other geomorphic classes also.

LOCALITY FACTORS.—The type occurs in the less arid portions of the regional distribution of the thorn forest, typically with about 600 to 750 mm. annual rainfall on intensively drained ground and dry porous soils generally; it gives way to the semi-desert type where the rainfall decreases. The data given for Etawah are representative of the ravine tract.

The ground is usually broken either as the result of gully erosion of unconsolidated and intercalated alluvial soils or a low hilly configuration. The soil is often very shallow in the former type through the formation of hard limestone pan not far below the surface; elsewhere stiff yellow clay may create similar conditions.

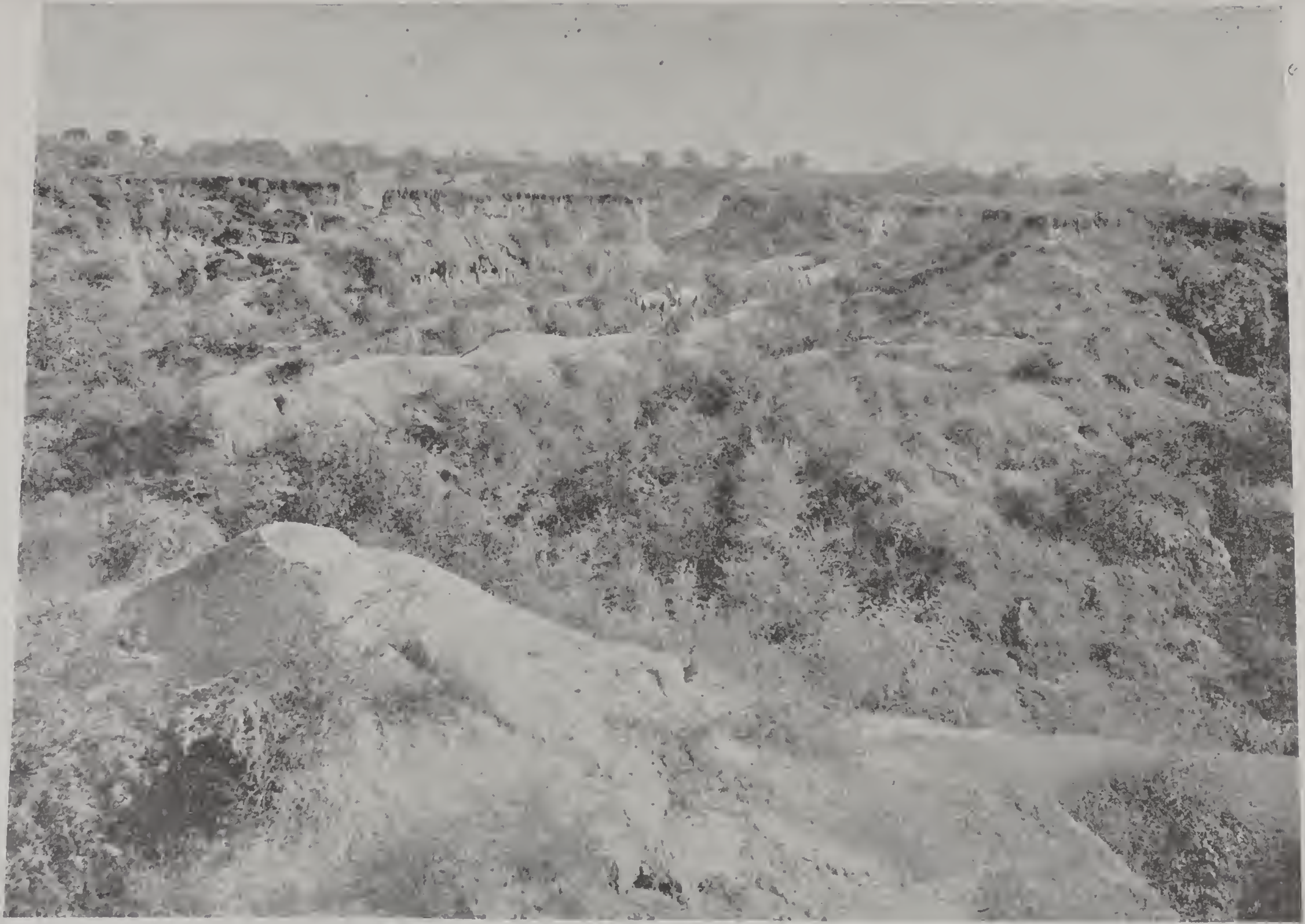
ILLUSTRATION.—Plate 60.

FLORISTICS.—

(i) *Bawain and Udi Blocks, Etawah* (Experimental Plots 9, 11).—

I. *Acacia leucophloea**, *Prosopis spicigera**, *Azadirachta indica* (o), *Holoptelea integrifolia* (vo), *Acacia arabica* (o), *Salvadora oleoides*, *Balanites aegyptiaca*, *Flacourtia indica.*

II. *Capparis decidua**, *C. sepiaria*, *C. zeylanica*, *Carissa opaca*, *Zizyphus* spp., *Dichrostachys cinerea**, *Calotropis procera*, *Adhatoda vasica.*



RAVINE THORN FOREST

Typical ravine area with thorny vegetation of *Acacia*, *Prosopis*, *Zizyphus*, *Capparis*, etc.

Manpur, Etawah, Uttar Pradesh.

E .A. Smythise

IVa. *Tephrosia purpurea*, *Cassia tora*, *Echinops echinatus*, *Xanthium strumarium*, *Argemone mexicana*, *Solanum xanthocarpum*, *Grewia* sp.

IVb. *Desmostachya bipinnata* (l), *Heteropogon contortus*, *Apluda mutica* (la), *Cenchrus ciliaris*, *Bothriochloa pertusa*, *Aristida* spp. (a), *Dichanthium annulatum*, *Eremopogon foveolatus* (o), *Eragrostis tenella*, *Chloris virgata*.

V. *Vallaris solanacea*, *Cocculus hirsutus*.

NOTE.—The forest along the Chambal ravines in Madhya Pradesh are continuous with the above and very similar.

GENERAL NOTE.—It has been stated that much of this heavily eroded ravine land once carried good sal forest (BENSKIN) and that it provides a fine example of retrogression consequent on denudation and erosion. Of the progress of the erosion there is no question but it may be doubted whether the climax was ever better than dry deciduous forest.

(ii) *N. W. Madhya Pradesh* (General floristics).—

I. *Acacia leucophloea**, *Tecomella undulata*, *Prosopis spicigera*, *Tamarix aphylla*.

II.& III. *Vitex negundo* (o), *Ehretia laevis* (o), *Securinega virosa* (o), *Clerodendrum phlomoides* (o), *Commiphora mukul* (o), *Carissa* sp. (f), *Adhatoda vasica* (f), *Capparis decidua* (f), *Capparis sepiaria* (r), *Zizyphus nummularia* (f), *Alhagi camelorum* (f), *Calotropis procera* (f), *Grewia* sp. (o), *Euphorbia* sp. (o), *Salvadora oleoides*.

IVa. *Cassia tora* (a), *Achyranthes aspera* (a), *Xanthium strumarium*.

IVb. *Themeda quadrivalvis* (f), *Heteropogon contortus* (a), *Aristida* spp. (a).

V. *Tinospora cordifolia* (o), *Capparis zeylanica*.

(iii) *Mahendragarh, Hissar, Punjab*.—

I. & II. *Acacia senegal**, *A. leucophloea**, *Prosopis spicigera**, *Salvadora oleoides**.

III. *Capparis decidua*, *Zizyphus mauratiana*, *Z. nummularia*, *Calotropis procera*, *Tephrosia purpurea*.

IVb. *Aristida depressa*, *Dichanthium annulatum*, *Heteropogon contortus*.

(iv) *Gurla Forest, Chittorgarh Division, Rajasthan*.—

I. & II. *Acacia leucophloea** (c), *Prosopis spicigera** (o), *Balanites aegyptiaca* (o), *Acacia arabica* (r), *Capparis decidua** (c), *Diehrostachys cinerea* (c), *Butea monosperma* (la), *Phoenix sylvestris* (o).

III. *Zizyphus nummularia*, *Mimosa rubicaulis* (c), *Securinega leucopyrus* (o), *Capparis sepiaria*.

IVa. *Tephrosia purpurea* (c), *Ocimum callum*, *Cassia tora*, *Indigofera cordifolia*, *Sida* spp., *Borreria hispida*, *Glinus lotoides*, *Sweda* sp., *Salsola* sp.

IVb. *Sehima nervosum*, *Apluda mutica*, *Heteropogon contortus*, *Cymbopogon martinii*, *Dichanthium annulatum*, *Aristida* spp., *Cenchrus barbatus*, *Eragrostis* spp., *Chloris inflata*, *Cynodon dactylon*, *Bothriochloa pertusa*, *Sporobolus marginatus*.

V. *Asclepiad* climbers (o).

NOTE.—Wherever the soil is reddish and gravelly the awned grasses such as *Aristida*, *Heteropogon*, and *Chrysopogon* take an upper hand. *Salvadora* and *Rhus mysorensis* predominate on waste lands (the latter on foothills) and *Sweda*, *Salsola*, *Glinus*, *Sporobolus* on saline soils. Nearby the habitat is favourable enough for dry deciduous forest (*Boswellia* and *Anogeissus pendula* types).

DS1. Zizyphus scrub

Common throughout the thorn belt, intermingled with the *Euphorbia* type which is slightly more conspicuous in rocky areas, and owing its origin to intense biotic pressure.

ILLUSTRATION.—Plate 61.

FLORISTICS.—

(i) *Western Rajasthan.*—

I. & II. *Acacia leucophloea** (c), *Dichrostachys cinerea**, *Zizyphus nummularia** (c), *Acacia senegal* (o), *Anogeissus pendula* (o), *Prosopis spicigera* (o).

III. *Capparis decidua*, *Securinega*, *Cassia tora.*

IVb. Thin *Aristida*, *Agrostis*, *Heteropogon.*

NOTE.—*Zizyphus* may have colonised old cultivation or old cutting. The *Acacia* is lopped and browsed and the area heavily grazed.

(ii) *Jodhpur, Rajasthan.*—

I. *Prosopis spicigera** (o).

II. *Zizyphus nummularia.**

IVb. Grass.

NOTE.—This form must also have originated similarly to (i) above.

DS2. Tropical Euphorbia scrub

More or less common throughout the thorn belt, especially conspicuous in Gujarat and western Rajasthan. Like the *Zizyphus* scrub this also owes its present form to excessive grazing and felling of tree growth but edaphic factors are also possibly involved. It occupies stony sites in general.

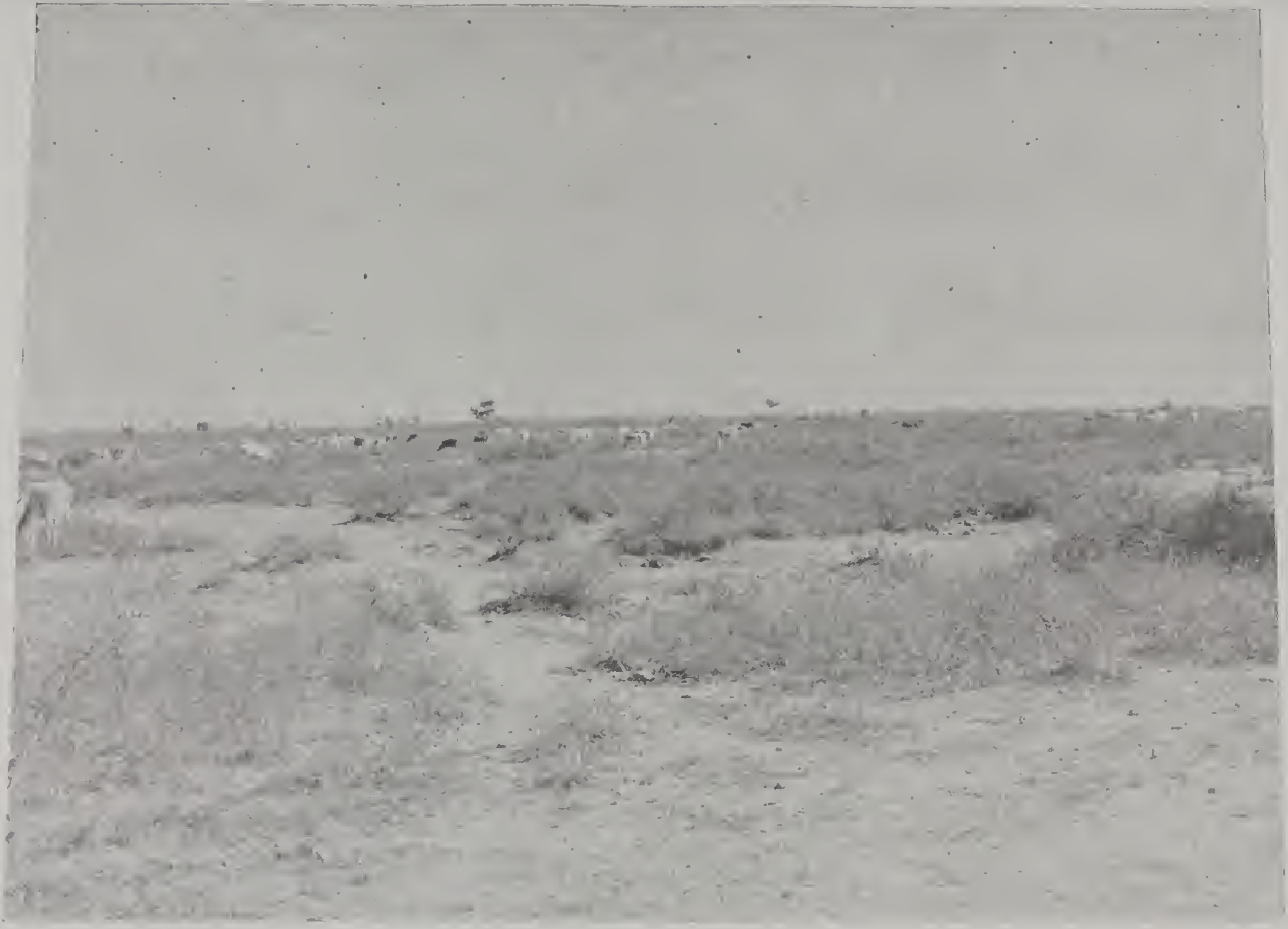
ILLUSTRATION.—Plate 62.

FLORISTICS.—

(i) *Jodhpur* (*Kailana, Mandor*), *Rajasthan.*—

I. & II. *Euphorbia neriifolia**.

III. *Rhyncosia minima*, *Grewia tenax*, *Crotalaria burhia*, *Sida* spp., *Barleria acanthoides*, *Aerva javanica*, *Tephrosia* spp., *Justicia simplex.*

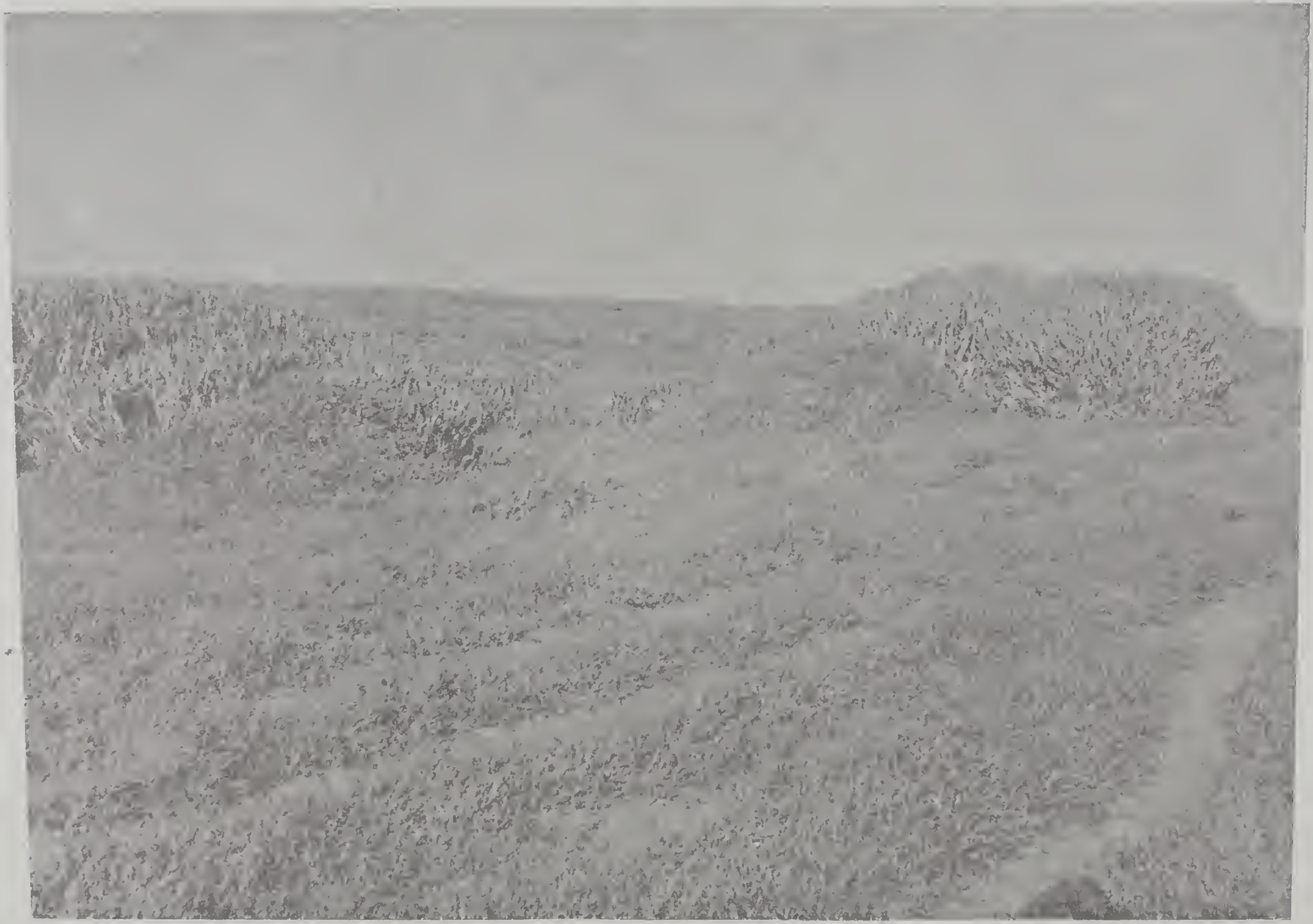


ZIZYPHUS SCRUB (THORN FOREST)

Zizyphus mauratiana and some *Dichrostaychs cinerea* all reduced to bushes by excessive browsing.

Kota Division, Rajasthan.

G.S. Mathauda



TROPICAL EUPHORBIA SCRUB

Extensive *Euphorbia* scrub near Dwarka, Saurashtra, Gujarat.

S. K. Seth

IVb. *Aristida* spp., *Eleusine* spp., *Dactyloctenium scindicum*, *Dichanthium annulatum*.

V. *Sarcostemma acidum*, *Convolvulaceae*.

(ii) *Jaipur* (*hills*), *Rajasthan*.—

I. *Euphorbia neriifolia**.

II. *Rhus mysorensis* (*Adhatoda vasica*, *Capparis divaricata*).

IVa. *Lindenbergia indica*, *Actiniopteris dichotoma*.

IVb. *Lasiurus scindicus*.

V. *Cocculus hirsutus*.

(iii) *Western Rajasthan*.—

I. *Euphorbia neriifolia**.

II. & III. *Solanum albicaule*, *Capparis decidua*, *Rhyncosia minima*, *Grewia tenax*, *Vernonia cinerascens*, *Salvadora oleoides*, *Mimosa hamata*.

(iv) *Deogarh*, *Udaipur* (*Rajasthan*).—

I. & II. *Rhus mysorensis*, *Euphorbia nivulia**.

III. *Zizyphus nummularia*, *Euphorbia hirta*, *Indigofera cordifolia*, *Cassia auriculata*, *Pupalia* spp., *Andrographis* spp., *Aerva* spp.

IVb. *Aristida*, *Andropogon*, *Melanocenchris*, *Cenchrus* spp., *Eragrostis* spp.

V. Absent.

(v) *Kutch*, *Gujarat*.—

I. & II. Stunted *Acacia senegal* (o), *Acacia leucophloea*, *Gymnosporia spinosa*, *Sarcostemma acidum*, *Euphorbia neriifolia**, *E. nivulia**, *Premna* spp.

III. *Grewia* spp., *Barleria*.

IVb. *Apluda mutica*.

V. *Vitis*, *Rivea*, *Tinospora*, *Tragia*.

(vi) *Dwarka*, *Saurashtra*, *Gujarat*.—

I. *Euphorbia antiquorum**, *E. neriifolia**.

II. *Capparis decidua*.

III. *Faqonia cretica*, *Arthrocnemum indicum*.

IVb. *Cynodon dactylon*, *Sporobolus marginatus*, *Eragrostis ciliaris*.

EDAPHIC AND DEGRADATION TYPES OF THORN FORESTS

E1. (Euphorbia scrub)

This is described under types 6A/DS2 (p. 233) and 6B/DS2 (p. 242).

E2. Acacia senegal forest

DESCRIPTION.—Typically an open overwood of pure *Acacia senegal* with few associates and little undergrowth.

DISTRIBUTION.—Western Rajasthan, Saurashtra, Kutch.

LOCALITY FACTORS.—As for the type. The species occurs on more xerophytic sites, e.g. blown or unconsolidated (but stationary) sand deposites, on quartzites (Jaipur) or limestones (Jaisalmer).

ILLUSTRATION.—Plate 63.

FLORISTICS.—

Galta, Jaipur Division, Rajasthan (on level blown sand)—

I. *Acacia senegal**, (*Prosopis spicigera* (o), *Acacia leucophloea*).

II. *Gymnosporia spinosa* (o), *Acacia jacquemontii.*

III. *Sericostema pauciflora, Indigofera argentea, Zizyphus nummularia.*

IVb. *Aristida* spp., *Sporobolus, Eragrostis.*

E3. Rann saline thorn scrub

All along the extensive marine saline flats (known as the *Rann* and occupying an area of 44,000 sq. km. in Gujarat) periodically inundated by the sea for longer or shorter periods the natural vegetation is very sparse. Rather further inland it consists mainly of occasional *Salvadora oleoides* and *Tamarix ericoides* with a few *Calotropis procera* and some *Indigofera* in the more saline areas further north in Kutch extensive *banni* grasslands, bordered by degraded *Acacia* forests, occur on the saline soil.

In this tract *Prosopis juliflora* was introduced in the eighties of the last century and has not only secured a foothold but is rapidly spreading and is now by far the most important economic species of these regions, and it is being increased through afforestation. Since *Prosopis juliflora*, although an exotic, imparts a characteristic physiognomy to these forests it is considered desirable to erect a separate subtype for these saline thorn forests.

ILLUSTRATIONS.—Plates 64 and 65.

NOTE.—The large trees in the background have come in naturally. Mesquite plantation being raised in the foreground.

E4. Salvadora scrub

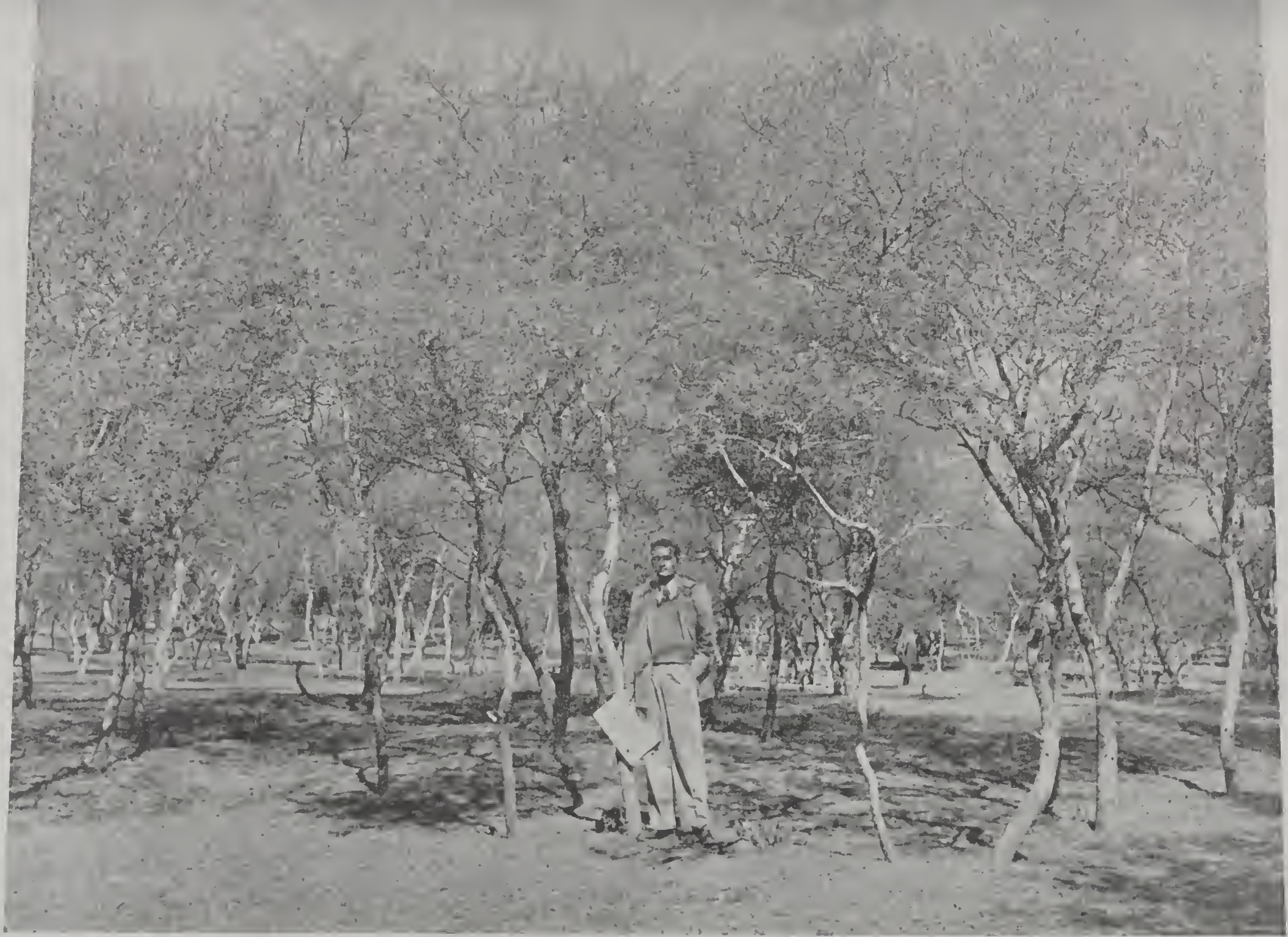
This association is characteristic of semi-arid or arid saline/alkaline soils and is met with from western Uttar Pradesh westwards.

ILLUSTRATION.—Plate 66.

FLORISTICS.—

(i) *Jaipur, Rajasthan.*—

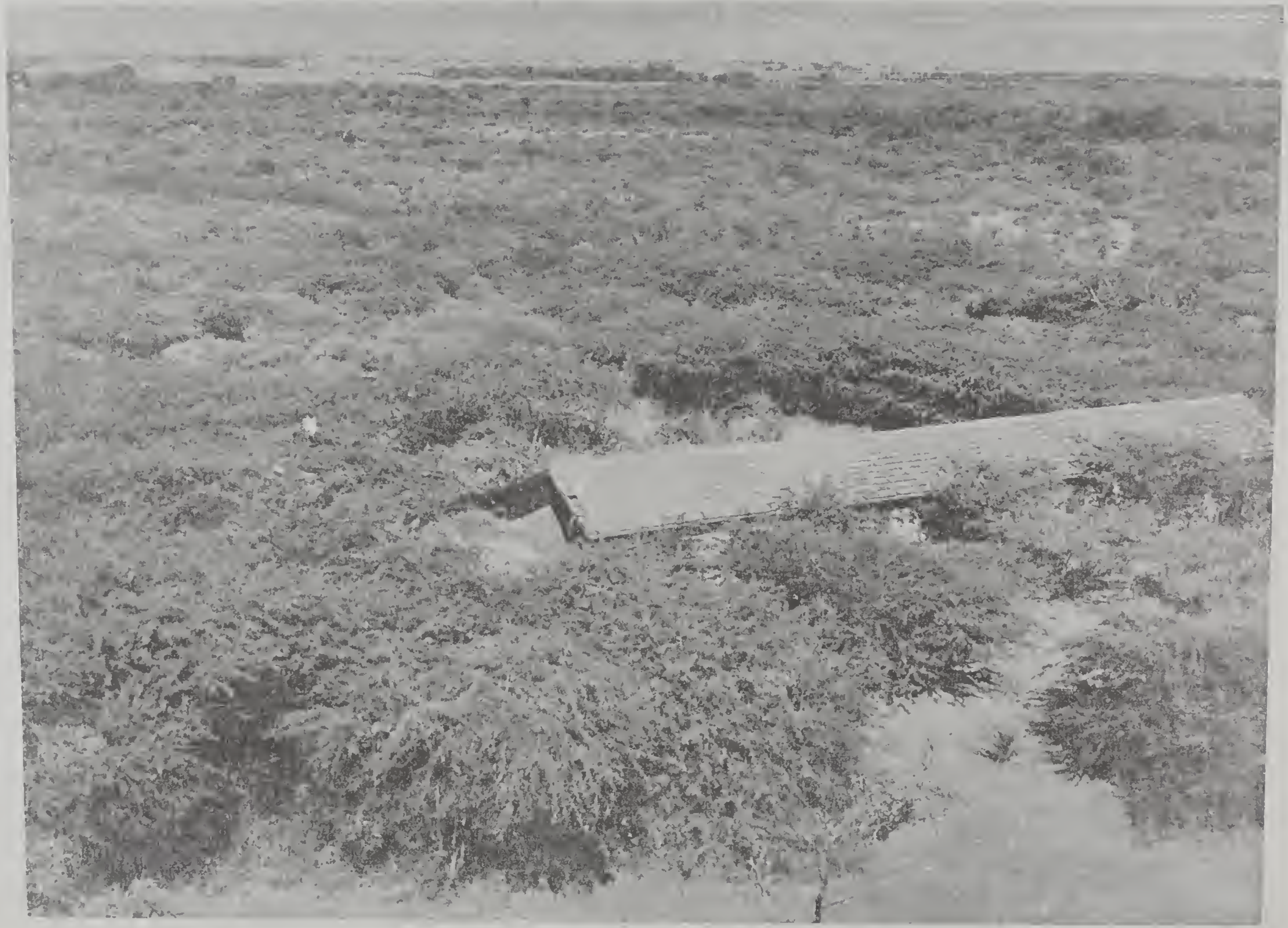
*Salvadora oleoides**, *S. persica**(o), *Tamarix aphylla**.



ACACIA SENEGAL FOREST
Pure crop on level ground, sandy loam soil.
Jaipur, Rajasthan.

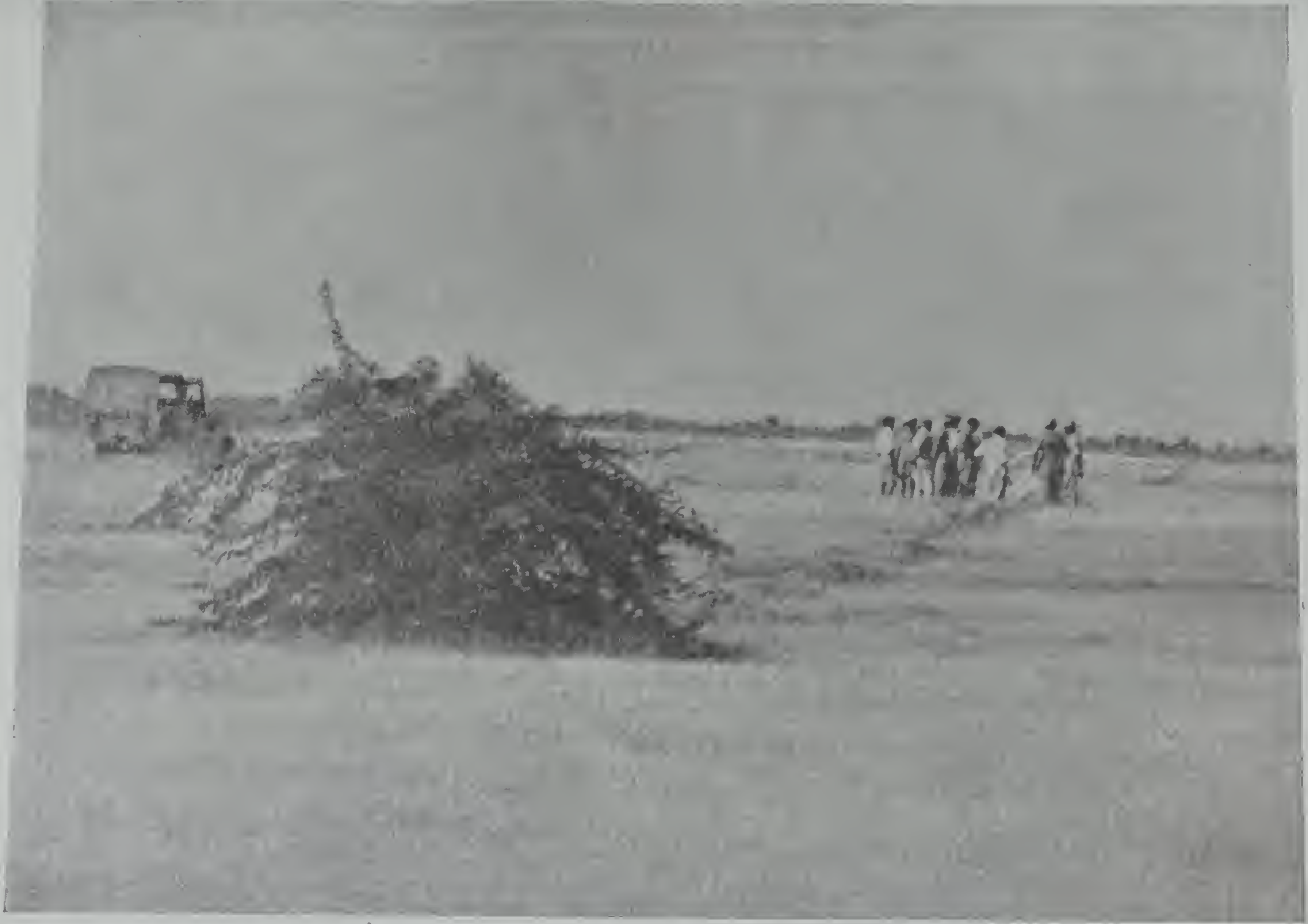
G. S. Mathauda

7 FRI&C/64]



RANN SALINE THORN FOREST

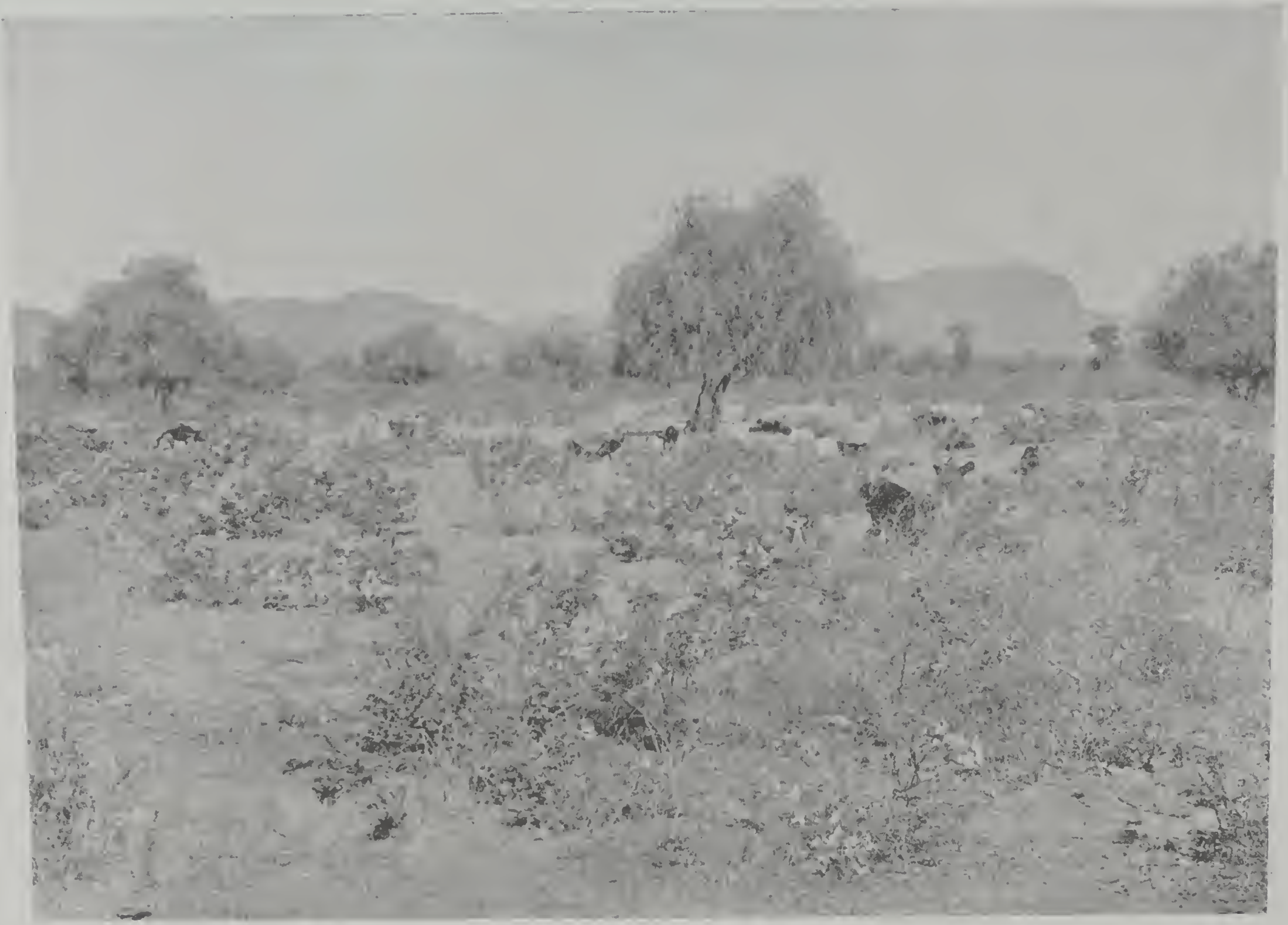
A closed protected forest of *Prosopis juliflora* (dark tone) with *Acacia suma*, *A. senegal* and *A. leucophloea*.



RANN SALINE THORN FOREST

Natural extension of *Prosopis juliflora* on saline flats, dispersal aided by *Equus onager*, the wild ass, which feeds on pods, the seeds passing undamaged in droppings. Near Dharangadhara, Saurashtra.

S. K. Seth



SALVADORA-CASSIA AURICULATA SCRUB
Common degraded scrub type, Sirohi, Rajasthan.

S. K. Seth

(ii) *Kutch, Saurashtra, Gujarat.*—

I. & II. *Salvadora oleoides**, *S. persica**, *Tamarix ericoides**.

III. *Calotropis procera*, *Indigofera* spp.

IV. *Sueda fruticosa*, *Halopyrum mucronatum*, *Crypsis schoenoides* (near Rann).

DS1. Cassia auriculata scrub

Cassia auriculata is frequently associated with *Salvadora oleoides* in dry areas in arid or moderately saline soils. This is evidently the effect of selective removal or natural elimination of other associated species of the dry deciduous (p. 207) or thorn forests (p. 239) such that only *Salvadora* which is of little use, and *Cassia* which coppices very well, are left as residual vegetation. Often the *Salvadora* is absent and almost pure *Cassia auriculata* scrub with a thin sprinkling of grass is left. The areas are subject to heavy browsing, grazing and frequent fires.

ILLUSTRATION.—Plate 66.

1S1. Desert dune scrub

DESCRIPTION.—A very open and irregular formation of stunted trees and bushes covering only a small proportion of the soil. The trees are thorny and all vegetation is markedly xerophytic.

DISTRIBUTION.—Southern Punjab and Rajasthan.

LOCALITY FACTORS.—The climate is that of the drier parts occupied by the northern mixed thorn forest and the type is determined by the soil which is dry and sandy and usually unstable. The sand is mounded up by wind into typical dune forms on the plains of the Indus valley and areas west of Aravallis.

ILLUSTRATION.—cf. Plate 58.

FLORISTICS.—

(i) *Jhumpa, S. Punjab* (on partially stabilised dunes)—

I. *Prosopis spicigera**, *Acacia arabica*, *Tamarix aphylla*, *Salvadora oleoides* (all r).

II / III. *Calotropis gigantea*, *C. procera*, *Zizyphus nummularia*, *Z. mauratiana*, *Calligonum polygonoides**, *Balanites aegyptiaca*, *Capparis decidua*, *Leptadenia pyrotechnica**, *Aerva javanica**, *Crotalaria burhia**.

IVb. *Cenchrus biflorus*, *Erianthus munja*.

(ii) *Jhunjhunu, Rajasthan* (on shifting dunes)—

I. & II. *Prosopis spicigera**, *Acacia arabica* (all r), *Zizyphus nummularia*, *Capparis decidua*, *Leptadenia pyrotechnica**, *Crotalaria burhia**, *Calotropis procera*.

III. *Sida cordifolia*, *Aerva pseudotomentosa*, *A. tomentosa*.

IVb. *Desmostachya bipinnata*, *Erianthus munja*, *Aristida* spp., *Eragrostis* spp., *Cynodon dactylon*.

NOTE.—Sand mixed with gravel (common in western Rajasthan), probably produced by the sorting action of the wind, supports a distinct type of vegetation. The tree species are *Prosopis spicigera*, *Salvadora oleoides*, *Gymnosporia spinosa*, *Capparis decidua* and conspicuous streches of *Zizyphus nummularia* (Jaisalmer) or *Acacia senegal* and *Euphorbia royleana* (Jodhpur). *Leptadenia pyrotechnica*, *Cleome papillosa*, *Boerhaavia diffusa* are common towards Jaisalmer. In gravel communities, *Indigofera* spp , *Fagonia cretica*, *Breweria latifolia*, *Sericostoma pauciflora*, *Tribulus* spp. are also common.

ECOLOGICAL NOTES.—Many accounts of the course of succession on sand dunes have been published (see especially BLATTER and HALLBERG, 1918). The information is briefly summarised here.

Pioneers.—On dunes: *Calotropis procera*, *Leptadenia pyrotechnica*, *Crotalaria burhia*, *Indigofera argentea**, *Aerva pseudotomentosa*, *Citrullus colocynthis*, *Farsetia jacquemontiana*, *Lasiurus hirsutus*, *Panicum turgidum*, *Eleusine* spp.

On spread out sand: (in order of appearance)

(i) *Aerva tomentosa*, *Aerva pseudotomentosa*.

(ii) *Leptadenia pyrotechnica* (*Capparis decidua* absent in westernmost region), *Panicum turgidum*.

(iii) *Crotalaria burhia*.

(iv) *Crotalaria-Leptadenia-Aerva pseudotomentosa-Panicum* association.

(v) *Crotalaria* (with *Convolvulaceae*, *Polygala* spp., *Breweria latifolia*) Jaisalmer.

Vegetation of stabilised dunes :

(i) Foot and lower slopes : *Aerva-Crotalaria*, then *Aerva*.

(ii) Upper slopes : *Panicum turgidum*, *Cenchrus ciliaris*, *Indigofera argentea* (o), *Rhyncosia arenaria* (r), *Cyperaceae* (esp *Cyperus arenarius*).

(iii) Top : *Calligonum polygonoides*.

Common grasses : *Eragrostis tremula*, *E. ciliaris*, *Cenchrus biflorus*, *C. prieurii*, *C. ciliaris*.

DABADGHAO (1960) has classified the grassland type as *Dichanthium-Cenchrus-Lasiurus*. *Lasiurus hirsutus* sometimes forms extensive and pure communities; *Panicum antidotale* also sometimes occurs in conspicuous associations.

GROUP 7. TROPICAL DRY EVERGREEN FORESTS

C1. Tropical dry evergreen forest

NOMENCLATURE

Andhra Pradesh—Dry evergreen forest (TROUP, etc.).
Carnatic evergreen.

GENERAL DESCRIPTION

A low forest, 9 to 12 m. high, but forming a complete canopy consisting mostly of small coriaceous leaved evergreen trees with short boles and spreading crowns. The proportion of deciduous species may be large locally. There is no marked differentiation of canopy layers between the shrubby underwood which includes many spiny species and the top canopy. A few species form the bulk of the crop which is, however, decidedly a mixed type, pure consociations being exceptional. Climbers are numerous. Bamboos are rare or absent. Grass is present but not conspicuous. Most of the forests have been much influenced by felling, lopping and browsing and have become irregular with open patches, and the thorny and unpalatable species have largely displaced the climax vegetation.

DISTRIBUTION

This type is restricted to the Karnatak coast where unusual climatic conditions prevail. It is found on the east coast from Tirunelveli northwards to Nellore. Similar forest referred to as "Dry zone forest" occurs over large areas in Ceylon and there is better developed than in India though much of it is known to be of secondary origin after clearing at very varying periods.

LOCALITY FACTORS

Temperature.—The following table gives the seasonal data for stations in the tract in which the type occurs. Of these Masulipatam and Madras are right on the coast and so enjoy a more equable and damper climate than usual, whilst Tiruchirapalli and Madura are far inland at the opposite extreme, but it will be noted that the differences are small.

Mean annual temperature is 27° to 28°C, the hottest month being May or June with a mean temperature of 30°—31° C. The coldest months are December and January with a mean temperature of 23°—24·5° C. The mean maxima and minima of the year are about 42° C and 15° C.

Rainfall and Humidity.—For the same stations the data are given in the attached table. The rainfall is very largely from the retreating or N. E. monsoon with maximum falls in October and November. The inland stations shew a subsidiary maximum in May ascribable to the S. W. monsoon with a definite break between the two rainy seasons, whereas the coastal stations shew a slow but continuous increase from May onwa The dry period is longest at Masulipatam with 6 months (December to May) with less than 50 mm. monthly, but is only 3 months at Madura (January-March). The mean humidity for the year is 82 at all these stations except Masulipatam where it is as low as 74.

Soil and Physiography.—The tract occupied varies a good deal with low hills and flats between. The soil is typically lateritic but the type is also developed to some extent on dune sands.

Temperature (centigrade)

Southern Dry Evergreen Forests

Month	Andhra Pradesh MASULIPATAM 3 m.			Madras MADRAS 20 m.			Madras VELLORE 214 m.			Madras TIRUCHIRAPALLI 78 m.			Madras MADURA 133 m.		
	Mean	Mean max.	Mean min.	Mean	Mean max.	Mean min.	Mean	Mean max.	Mean min.	Mean	Mean max.	Mean min.	Mean	Mean max.	Mean min.
January	23·6	28·3	18·9	24·6	29·6	19·5	23·4	28·8	17·9	25·4	30·7	20·1	25·1	29·9	20·2
February	25·2	30·1	20·3	25·8	31·3	20·2	25·3	31·6	19·0	27·1	33·4	20·7	26·6	32·4	20·8
March	27·4	32·5	22·4	27·7	33·0	22·4	27·8	34·6	21·0	29·6	36·2	22·8	28·8	35·2	22·5
April	30·0	34·6	25·4	30·4	35·3	25·6	30·8	37·1	24·6	31·8	38·1	25·6	27·9	36·6	24·8
May	32·6	37·5	27·6	33·1	38·5	27·6	32·4	38·8	26·1	32·4	38·6	26·2	31·3	37·1	25·6
June	31·9	36·8	27·1	32·4	37·6	27·3	31·1	36·2	25·9	31·6	37·1	26·1	30·9	36·2	25·6
July	29·6	33·6	25·6	31·0	35·7	26·3	29·8	34·5	25·1	30·9	36·1	25·7	30·3	35·5	25·2
August	29·2	32·9	25·5	30·4	34·9	25·8	29·3	34·0	24·6	30·4	35·8	25·1	29·9	35·1	24·7
September	28·9	32·5	25·3	29·8	34·4	25·1	28·8	33·4	24·1	27·1	35·2	24·6	29·4	34·3	24·4
October	27·9	31·4	24·4	28·1	32·3	23·9	27·2	31·6	22·7	28·4	33·0	23·7	28·0	32·3	23·7
November	25·6	29·3	21·8	25·9	29·7	22·2	24·8	29·1	20·6	26·5	30·6	22·4	26·6	30·4	22·8
December	23·7	28·1	19·2	24·7	28·9	20·5	23·1	28·0	18·2	25·3	29·7	20·9	25·3	29·3	21·2
M. A. T.	27·9	..	..	28·7	..	..	27·8	..	..	29·1	..	..	28·6	..	..
Annual mean maximum	32·3	..	..	33·4	..	..	33·2	..	..	34·6	..	..	33·7	..	..
Highest record	47·8	..	..	45·0	..	..	44·4	..	..	43·9	..	..	42·2	..	..
Annual mean minimum	23·6	..	..	23·9	..	..	22·5	..	..	23·7	..	..	23·4	..	..
Lowest record	13·9	..	..	13·9	..	..	12·2	..	..	13·9	..	..	15·6	..	..
No. of years	60	..	..	60	..	..	40	..	..	60	..	..	60	..	..

Rainfall (millimetres)

Southern Dry Evergreen Forests

Month	Andhra Pradesh MASULIPATAM 3 m.	Madras MADRAS 20 m.	Madras VELLORE 214 m.	Madras TIRUCHIRAPALLI 78 m.	Madras MADURA 133 m.
January	5	36	37	25	20
February	14	10	6	12	14
March	11	7	7	9	18
April	18	16	25	46	55
May	34	26	58	84	70
June	107	47	70	41	40
July	162	91	116	34	50
August	159	116	146	97	104
September	162	119	175	120	119
October	218	306	173	183	189
November	147	355	195	148	146
December	17	138	67	71	51
Total for year (M.A.R.)	1,052	1,268	1,074	872	873
Number of rainy days	55	57	57	47	51
Number of months with less than 50 mm.	6	6	4	6	5
M. A. Humidity	74	57	64	60	60
No. of years	60	60	40	60	60

FLORISTICS.—The most conspicuous genus is *Manilkara* (*Sapotaceae*); *Memecylon* (*Melastomaceae*) is also typical and common. *Diospyros* and *Eugenia* and sometimes *Chloroxylon* and *Albizzia amara* are present.

(i) *General.*—

I/II. *Manilkara hexandra**, *Mimusops elengi**, *Diospyros ebenum*, *Strychnos nux-vomica*, *Eugenia* spp., *Drypetes sepiaria* (r).

III. *Memecylon edule**.

NOTE.—The type has been little studied.

(ii) *Nagavera, S. Cuddapah Division, Andhra Pradesh.*—

I. *Manilkara hexandra** (la), *Canthium dicoccum* (f), *Zizyphus glaberrima* (f), *Acacia leucophloea* (f), *Randia dumetorum* (lf), *Buchanania angustifolia* (o), *Strychnos nux-vomica* (o), *S. potatorum* (o), *Sapindus emarginatus* (o), *Diospyros chloroxylon* (o), etc.

II. *Carissa carandas* (a), *Flacourtia indica* (la), *Maba buxifolia* (f), *Grewia* sp. (a), *Gymnosporia* spp. (f), *Ixora arborea* (f), *Webera* sp. (lf).

III. *Strobilanthes* sp. (a), *Dodonaea viscosa* (la).

IVb. Grass light.

V. Climbers abundant. *Derris scandens* (f), *Asparagus* sp. (f), *Acacia intsia* (a), *Pterolobium indicum*, *Zizyphus oenoplia* (a), *Combretum* sp. (f).

Note.—This provides an example of transition to dry deciduous forest with *Anogeissus latifolia* etc. The prevalence of thorny species is probably largely due to human agencies.

(iii) *Sriharikota Island, Nellore Division, A.P.* (*P.P.* 1).—

I. *Manilkara hexandra**, *Syzygium cumini*, *Albizzia amara**, *A. lebbek*, *Strychnos nux-vomica*, *Drypetes sepiaria*, *Ficus tsilea*, *Sapindus emarginatus*, *Tamarindus indica*, *Azadirachta indica*, *Pterospermum suberifolium*, *Borassus flabellifer*.

II. *Memecylon umbellatum**, *Maba buxifolia**, *Garcinia spicata*, *Crataeva religiosa*, *Atalantia monophylla*, *Cordia dichotoma*, *Gmelina arborea*, *Phoenix sylvestris*, *Flacourtia indica*.

III. *Glycosmis pentaphylla*, *Ochna squarrosa*, *Randia* spp.

IV. *Sarsaparilla*, some grass.

V. *Calamus viminalis*.

DS1. Tropical dry evergreen scrub

Much of the climax forest has been degraded resulting in the disappearance of the trees; the remnants are thorny shrubs. There is thin grass.

FLORISTICS.—

(i) *Vandalur, Saidapet Divn., Madras.*—

*Memecylon edule**, *Zizyphus glaberrima*, *Dichrostachys cinerea*, *Randia dumetorum*, *Carissa spinarum*.

(ii) *Navalur, Madurantakam, Madras.*—

*Memecylon edule**, *Albizzia amara*, *Buchanania lanzan*, *Maba buxifolia*, *Randia dumetorum*, *Carissa spinarum*, *Dodonaea viscosa*.

CHAPTER VIII

MONTANE SUBTROPICAL FORESTS

GROUP 8. SUBTROPICAL BROADLEAVED HILL FORESTS

As there are considerable differences between the northern and southern representatives of subtropical forests, they will be described and discussed as two sub-groups *viz.*,

8A. Southern Subtropical Broadleaved Hill Forests.
8B. Northern Subtropical Wet Hill Forests.

Sub-group 8A. Southern Subtropical Broadleaved Hill Forests

1. NOMENCLATURE

Kerala *Madras* *Mysore* *Bombay*	Shola (part). Transition forest.
Rajasthan *Madhya Pradesh* *Orissa*	Hill top forest.

2. GENERAL DESCRIPTION

The forest presents two decidedly different aspects according as to whether it occurs with a well-distributed fairly high rainfall as on the higher hills in the south where the adjoining tropical forest is of the wet evergreen type, or with a lower unequally distributed rainfall with a marked dry season, where the adjoining tropical forest is of a dry deciduous type ; the latter conditions prevail on all the more isolated hills of the central part of the country and usually the original vegetation has been so altered by biotic influences that its form and composition can only be inferred. Accounts are given under the three types distinguished below.

3. DISTRIBUTION

Subtropical types are met with in a zone between about 1,000 m. and 1,700 m. on the higher hills of South India, and also above 1,000 m. on the higher hills of Central India including outliers such as Mt. Abu (1,360 m.) and Parasnath (1,220 m.) though mostly only in vestigial form.

4. LOCALITY FACTORS

Temperature.—The mean annual temperature lies roughly between 18° and 24° and the mean January temperature about 5° lower. Frost is practically unknown Data are given for Mercara at 1,158 m., Coonoor at 1,746 m., Mahabaleshwar at 1,381 m., and Mt. Abu at 1,200 m.

Temperature (centigrade)

Southern Subtropical Broadleaved Hill Forests

Month	Mysore MERCARA 1,143 m.			Maharashtra MAHABALESH-WAR 1,382 m.			Madhya Pradesh PACHMARHI 1,075 m.			Rajasthan MT. ABU 1,202 m.			Madras COONOOR 1,746 m.		
	Mean	Mean max.	Mean min.	Mean	Mean max.	Mean min.	Mean	Mean max.	Mean min.	Mean	Mean max.	Mean min.	Mean	Mean max.	Mean min.
January	19·6	25·1	14·0	18·8	23·6	13·9	15·5	22·2	28·7	14·6	18·6	10·4	13·7	19·0	8·3
February	21·0	27·0	15·0	19·9	25·2	14·6	17·2	24·1	10·4	15·9	20·0	11·7	15·3	21·0	9·5
March	22·7	29·0	16·4	22·5	28·0	17·0	22·1	28·9	15·2	20·4	24·8	16·1	17·0	22·7	11·3
April	23·2	28·7	17·7	24·3	29·7	18·9	26·9	33·3	20·4	24·6	29·1	20·2	18·7	23·7	13·7
May	22·4	26·7	18·1	23·5	28·8	18·2	29·7	35·4	23·9	26·5	31·1	21·7	19·8	24·6	15·0
June	19·8	22·3	17·3	19·2	21·4	16·9	26·6	31·0	22·2	24·5	28·7	20·3	18·8	22·6	15·1
July	18·6	20·4	16·7	17·7	18·6	16·8	22·3	24·7	19·9	21·5	24·1	18·9	18·3	21·6	15·1
August	18·7	20·7	16·7	17·6	18·7	16·4	21·6	23·8	19·3	20·1	22·2	18·0	18·0	21·6	14·3
September	19·3	22·1	16·6	17·9	19·9	16·0	22·1	25·3	18·9	21·1	24·0	18·2	17·6	21·7	13·5
October	20·5	24·1	16·9	19·9	23·4	16·3	20·8	26·6	14·9	22·1	26·2	18·0	17·2	20·9	13·4
November	19·9	23·9	16·9	19·1	23·3	14·9	17·0	23·6	10·4	18·8	23·2	14·3	15·7	19·4	11·8
December	19·1	23·8	14·3	18·1	22·6	13·6	14·8	21·8	7·7	15·8	20·2	11·4	14·1	18·7	9·6
M. A. T.	20·4	..	..	19·9	..	..	21·4	..	..	20·5	..	..	17·0	..	..
Annual mean maximum	24·5	..	..	23·6	..	..	26·7	..	..	24·3	..	..	21·4	..	..
Highest record	35·0	..	..	36·1	..	..	40·6	..	..	38·3	..	..	29·4	..	..
Annual mean minimum	16·3	..	..	16·1	..	..	16·0	..	..	16·6	..	..	12·6	..	..
Lowest record	8·9	..	..	6·7	..	..	—1·1	..	..	—1·1	..	..	2·2	..	..
No. of years	60	..	..	60	..	..	60	..	..	60	..	..	10	..	..

Rainfall and Humidity.—The range of average annual rainfall is a wide one whilst the length of dry season varies from virtually none to seven months. These differences tend to be offset by relatively high humidity and affect the vegetation less than might be expected, though closer study would probably reveal differences sufficient to render subdivision advisable. The different distributions at Gudalur and Coonoor on the north-west and south of the Nilgiri massif are noteworthy.

Rainfall (millimetres)

Southern Subtropical Broadleaved Hill Forests

Month	Madras COONOOR 1,746 m.	Madras GUDALUR 1,067 m.	Mysore MERCARA 1,143 m.	Maharashtra MAHABALESHWAR 1,382 m.	M. P. PACHMARHI 1,075 m.	M. P. CHIKALDA 1,097 m.	Rajasthan MT. ABU 1,202 m.
January . . .	63	9	4	4	16	15	7
February . .	73	7	6	3	17	10	6
March . . .	82	19	19	4	14	12	4
April . . .	149	71	65	30	9	9	9
May . .	106	131	132	41	16	21	24
June . . .	71	413	648	1,084	230	240	118
July . . .	66	737	1,095	2,675	666	511	559
August . . .	127	443	681	1,857	606	440	578
September . .	90	203	281	730	360	305	238
October . . .	257	176	211	161	58	88	19
November . .	285	82	76	40	19	34	6
December . .	142	18	18	7	11	15	3
Total for year (M. A. R). . . .	1,512	2,309	3,237	6,635	2,022	1,701	1,564
No. of rainy days .	85	114	132	120	79	77	54
No. of months with less than 50 mm.	0	4	4	7	7	7	8
Mean Annual Humidity . .	69	..	80	69	57	?	53
No. of years . .	10	64	60	60	60	61	60

Soil and Topography.—These types are restricted to hilly districts though rolling plateau country is included. A variety of rocks is encountered including basaltic trap (Mahabaleshwar). The soil is intermediate in type between the tropical red earths and the temperate brown earths. There may be a thick lateritic cap over trap rock and a typically lateritic soil (Mahabaleshwar), indicating a tropical rather than temperate history.

5. GENERAL FLORISTICS

In the south, the flora is a mixture of that of the wet tropical forest, especially of the wet evergreen type, with that of the temperate forest, the former element usually predominating. Further north, it is the dry tropical types that extend even to the tops of the hills, some species tending to dominate with a varying proportion of plants of temperate type among the subordinate vegetation. *Eugenia* (*Syzygium*) are characteristic genera and *Lauraceae* are very generally present. *Memecylon* and other *Melastomaceae* usually occur. Several studies of the phytogeography of these hill tops have been made revealing affinites with both Western and Eastern Himalayan floras. Genera of northern origin include *Clematis*, *Hypericum*, *Lonicera* and *Rubus*.

6. SUBDIVISIONS

These forests have all been subject to much interference and apart from their floristics have been inadequately studied to permit of a reliable classification. The following types are provisionally differentiated :

C1. Nilgiri subtropical hill forest.

DS1. South Indian subtropical hill savannah (woodland).

E1. Reed brakes (Ochlandra).

C2. Western subtropical hill forest.

C3. Central Indian subtropical hill forest.

C1. Southern subtropical hill forest

NOMENCLATURE.—Transition belt of shola forests.

DESCRIPTION.—Evergreen forest that has been described as 'stunted rain forest', similar to the tropical rain forest but not so luxuriant, the trees being smaller and with less shapely boles, and often festooned with herbaceous and cryptogamic epiphytes. A dense undergrowth of *Strobilanthes*, etc. is frequently present.

In S. India, notably on the slopes of the higher Nilgiri and Palni Hills no marked zonal differentiation of tropical, subtropical and temperate vegetational types is discernable, the first and last types are definite enough but they appear to merge imperceptably into each other without any intervening zone with characteristics differing from both. This is comparable in some respects with the frequent absence of well marked semi-evergreen forest between evergreen and deciduous forests, and the explanation is perhaps similar, *viz*., that it is due to the fact that the topography is such that the transition would in any case occupy relatively little space and the tropical and temperate forms would always be within a few miles of each other. In S. India the temperate forests are of a dense low evergreen type and the tropical wet evergreen falls off in height and general luxuriance with ascending elevation till the two are more or less alike. The transition zone has in any case been considerably affected by human interference, much of it having been subjected to shifting cultivation, burning or clearing for gardens. On the steeper slopes with shallow soil and rocky outcrops poor deciduous forest of a savannah type may replace the evergreen.

DISTRIBUTION.—Between 1,200 and 1,750 m. on the slopes of the Nilgiri, Anamalai and Palni Hills of Madras and Kerala, extending some distance northwards, doubtfully to Mercara (Coorg).

LOCALITY FACTORS.—Temperature data are given on p. 252 for Coonoor and Mercara and the rainfall data for Coonoor, Mercara and Gudalur (which is at the lower extreme for the type on the west side of the Nilgiri massif). The rainfall may vary from 2,000 to 5,000 mm. with a varying amount from the North-East monsoon.

FLORISTICS.—

(i) *Silent Valley, Palghat Division, Kerala, over* 1,550 *m.*—

I. & II. *Calophyllum elatum*, *Actinodaphne hookeri*, *Litsea stocksii*, *Cinnamomum sulphuratum*, *Canthium dicoccum*, *Eugenia* spp.*, *Rhododendron nilagiricum*, *Gaultheria frangitissima.*

III. *Strobilanthes* spp.

ECOLOGICAL NOTE.—This forest is protected from fire by the evergreen forests below. Much of it has been cleared for tea and coffee plantations. It may be viewed as a possible climatic climax formation though ill-defined and mainly transitional. Where the rainfall is low and fires occur, it changes into the next type described below (8A/C2).

(ii) *Thenmalai and Trivandrum, Kerala, cir.* 1,200 *m.* (transition to tropical).—

I. *Eugenia wightiana**, *E. arnottiana**, *Microtropis wallichianum*, *Kurrimia indica*, *Euphoria longana*, *Turpinia cochinchinensis*, *Meliosma wightii*, *Semecarpus travancorica*, *Linocera* spp., *Elaeocarpus venustus*, *Machilus macrantha*, *Neolitsaea zeylanica*, *Celtis* sp., *Heritiera papilio*, *Gordonia obtusa*, *Ficus arnottiana*, etc.

II. *Eugenia montana*, *Canthium dicoccum*, *Memecylon* sp., *Heptapleuron wallichianum.*

IIa. *Ochlandra* sp.

III. *Strobilanthes* sp.

V. *Calamus* sp.

DS1. South Indian subtropical hill savannah (woodland)

DESCRIPTION.—An open savannah forest with tall coarse grass even 2-3 m. high and scattered trees nearly all deciduous and fire hardy shrubs; *Phoenix humilis* is particularly characteristic.

DISTRIBUTION.—Between 1,100 m. and 1,700 m. on the slopes of the Nilgiri and Palni Hills of Madras and Kerala.

LOCALITY FACTORS.—Temperature and rainfall as for Kotagiri and Gudalur in the Nilgiri Hills (p. 253). The rainfall varies from 1,500 mm. upwards and is well distributed. On hilly country, especially on steep slopes, but often also on undulating plateau land. Mostly burnt at frequent intervals, usually annually.

FLORISTICS.—

I. *Dalbergia latifolia* (lower levels), *Anogeissus latifolia* (lower levels).

II. *Emblica officinalis*, *Wendlandia notoniana*, *Olea dioica*.

III. *Phoenix humilis**.

IVb. Heavy grasses.

NOTE.—The type is unquestionably a degradation stage derived from the subtropical evergreen by clearing or burning or both, and maintained by periodic burning. Only fire hardy trees occur. Locally on shallow soils the climax is perhaps only semi-evergreen or moist deciduous forest.

E1. Ochlandra reed brakes

DESCRIPTION.—Impenetrable thickets 3 to 5 m. high with scattered overwood of evergreen trees.

DISTRIBUTION.—Near the summit of the Tirunelveli hills above the evergreen forest and along the higher slopes at 800 m. and above, and especially along streams.

LOCALITY FACTORS.—Restricted to moist areas.

ILLUSTRATION.—Plate 67.

FLORISTICS.—

I. *Vernonia monosis* (o), *Eugenia* spp. (o), *Palaquium ellipticum* (o).

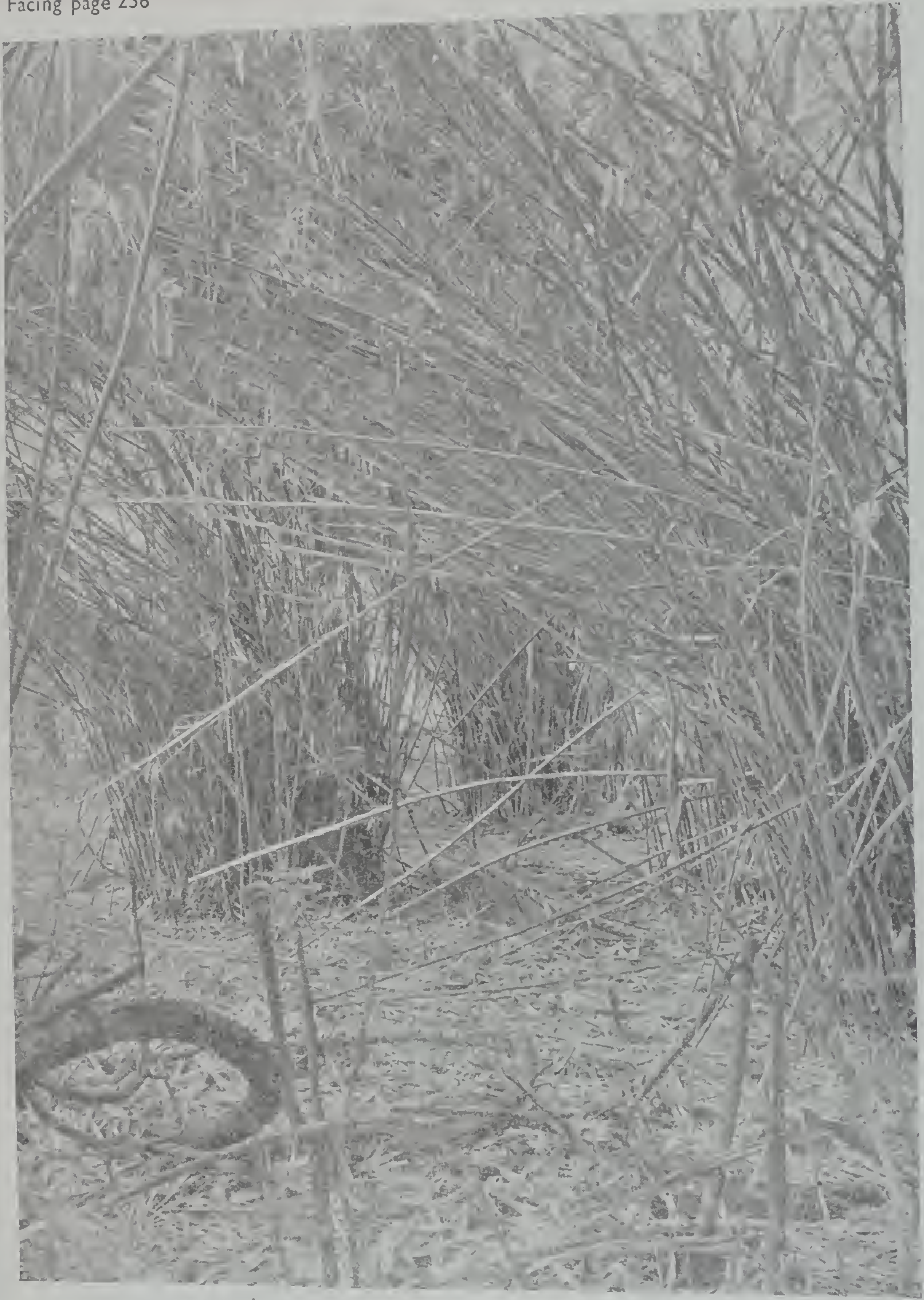
II. *Ochlandra wightii**, *O. travancorica**, *Bentinckia coddapanna* (a) (on rocky ground).

ECOLOGICAL STATUS.—Not determined but it appears able to invade chance gaps in the evergreen forest.

C2. Western subtropical hill forest

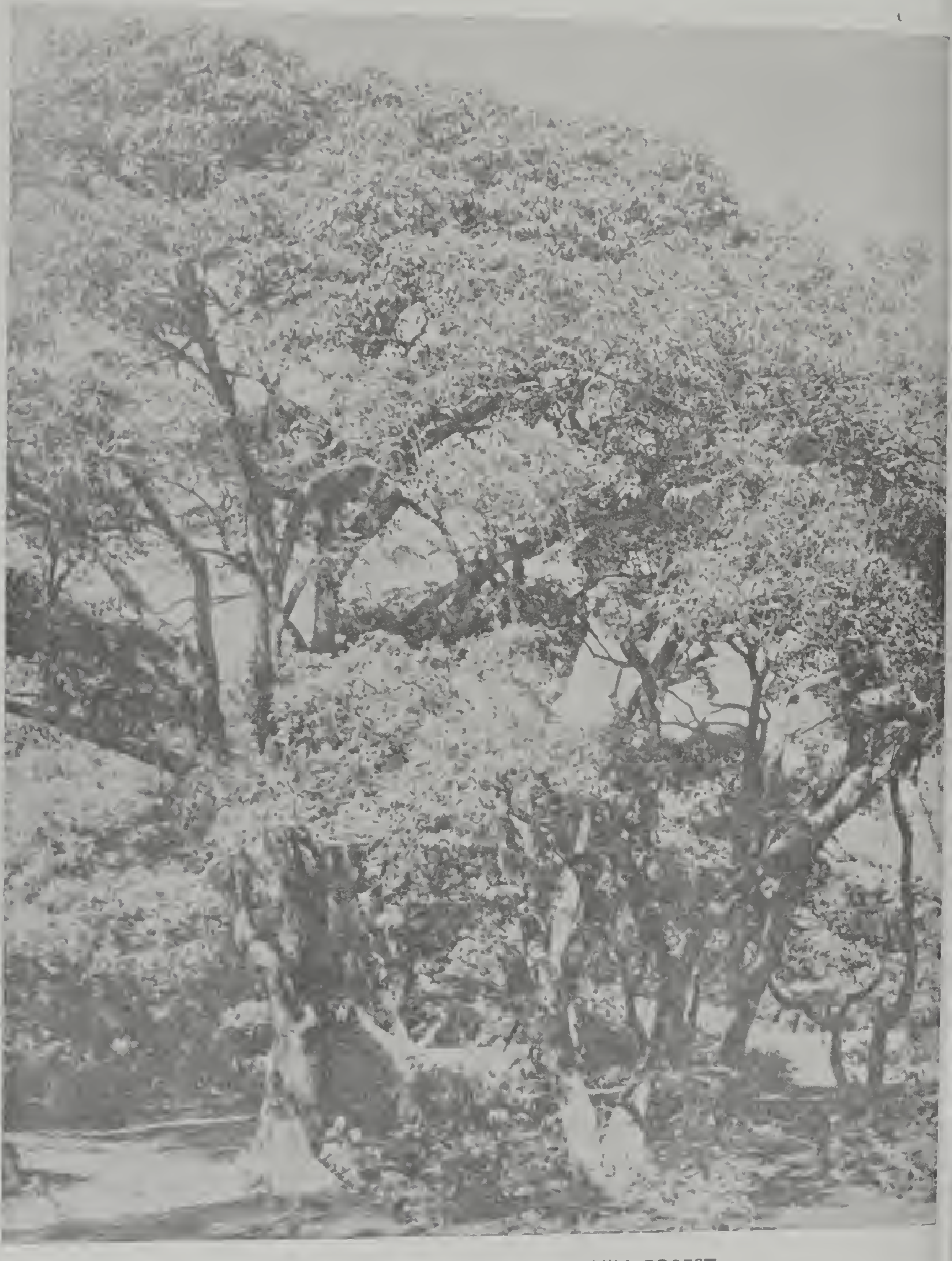
DESCRIPTION.—Most of the forest has been fundamentally altered by shifting cultivation or lopping. Where properly developed, it is a dense evergreen wood of mixed species and low height generally not exceeding 15 m. though locally up to 20 m. Trees of girth up to 2 m. occur, of spreading habit and usually hollow. There may be scattered emergents of *Tetrameles*, *Stereospermum*, etc.

DISTRIBUTION.—Above about 1,000 m., in the northern part of the Western Ghats in Bombay State.



REED BRAKES (OCHLANDRA)
Ochlandra sp. on alluvium forming dense dark brakes.
Chandanathode, Wynaad Division, Kerala.

H. G. Champion



CENTRAL INDIAN SUBTROPICAL HILL FOREST

Syzygium forest on plateau near Hidda R. H., Mahabaleshwar, Maharashtra.

H. G. Champion

LOCALITY FACTORS.—Climatic data are given on p. 253 for Mahabaleshwar which experiences an exceptionally heavy rainfall. The dry season is as long as seven months though humidity is fairly high. The rock at Mahabaleshwar is basaltic trap overlaid with a thick lateritic cap from which the soil derives its chief characteristics mostly unfavourable to good tree growth.

ILLUSTRATIONS.—Puri (1960); Figs. 82, 84-6.

FLORISTICS.—

(i) *Mahabaleshwar, Maharashtra.*—

I/II. *Syzygium cumini*, Actinodaphne hookeri, Memecylon umbellatum*, Randia dumetorum, Flacourtia latifolia, Terminalia chebula, Olea dioica, Glochidion hohenackeri, Pouteria tomentosa.*

III. *Canthium dicocium, Scutia myrtina* (thorny), *Carvia callosa* (*Strobilanthes callosus*), *Pogostemon plectranthoides, Lasiosiphon eriocephalus.*

IV. *Elaeagnus latifolia, Allophyllus cobbe, Capparis pedunculosa, Zizyphus rugosa, Pavetta indica.*

NOTE.—The forest is full of blanks due to old *kumris* which are very slowly recolonized by *Pteridium aquilinum* followed by *Crotalaria retusa, Lasiosiphon eriocephalus, Randia dumetorum* etc., which also occur generally on poor rocky sites, and ultimately by *Syzygium* and other climax species. PURI & MAHAJAN (1960) differentiate 3 more communities characterised by the predominance of *Terminalia chebula, Randia dumetorum* and *Artocarpus hirsuta* respectively, but they do not seem to be more than anthropogenic variants. SATYANARAYANAN (1958) records *Dysoxylum binectariferum* as a frequent emergent.

Very similar vegetation is found at Bhimashankar (PURI & VASVADA). Although these forests occur on a plateau at only 760 m., they closely resemble those of Mahabaleshwar. The rainfall is over 5,000 mm., humidity high, and temperatures moderate (Max. 28° C., Min. 20° C.).

C3. Central Indian subtropical hill forests

NOMENCLATURE.—

Madhya Pradesh	Hill top forests.
Bihar	
Orissa	
Rajasthan	

DESCRIPTION.—The sites occupied being exposed and often with poor soil, and long subject to human settlement and grazing, the residual forest is mostly of an inferior type, the trees being short-boled and branchy. It is doubtful if any climax forest survives though the vegetation of sheltered glens and steep and narrow gullies probably represents it to some extent. The average sites carry a more xerophytic vegetation which in its present degraded form closely resembles the tropical dry deciduous forest though usually with a rather higher proportion of evergreens.

DISTRIBUTION.—On hill tops over about 1,200 m. in Madhya Pradesh, Orissa and Bihar, such as Pachmarhi, Chikalda and the Bailadila Hills, probably also Mt. Abu and Parasnath.

LOCALITY FACTORS.—

Temperature.—The mean annual temperature ranges from 18° to 24°C, the January mean being about 5° C lower, and the May mean rising to about 23° C, reflecting the much longer dry season. Light frost is occasionally recorded at the higher elevations as at Mt. Abu (1,200 m.).

Rainfall and Humidity.—Rainfall is definitely lower than in the South Indian type though still relatively high, and is typically over 1,500 mm. mainly from the S.W. monsoon; there is however, a long dry season, usually lasting seven months which is not compensated by adequate humidity as the monthly average drops as low as 26 (even 20 at noon).

Soil and Topography.—Soils are typically shallow where the topography is steep as in Mt. Abu, but of fair depth on the flatter tops as in Pachmarhi. Laterite is usual. Pachmarhi is mainly on sandstones, but a wide variety of rocks are represented.

ILLUSTRATION.—Plate 68.

FLORISTICS.—Owing to the far reaching effects of clearing, grazing and burning, there is little left of the climax vegetation, but it would appear to consist mainly of tree species extending up from the mixed deciduous type below with predominance of *Syzygium cumini*, *Manilkara hexandra*, *Ficus* spp., *Mallotus* etc. and a shrubby undergrowth including *Strobilanthes*, *Ixora*, *Indigofera*, etc., and often lianes such as *Bauhinia*, *Vitis* and *Clematis*. Representatives of northern genera such as *Hypericum*, *Rubus*, *Berberis* are found, as well as *Pteridium*.

(i) *Pachmarhi, Madhya Pradesh.*—

The fairly extensive plateau lying at somewhat over 1,000 m. with peaks up to 1,350 m. might be expected to carry subtropical vegetation. Actually typical tropical dry deciduous forest extends right up to the rim whilst the plateau itself has been so greatly influenced by clearing etc. as to leave it uncertain what it carried originally. Evergreen *Manilkara hexandra**, *Mangifera** and *Syzygium cumini** are the conspicuous indigenous trees.

[cf. RAO & NARAYANASWAMI (1960), KAPOOR & YADAV (1962), and HEWETSON (1940)].

(ii) *Central Valleys, Bailadila Range, M.P.* (NOT SEEN).
(Carallia-Calamus-Cyathea association—MOONEY, 1941).

I. *Carallia brachiata** (f).

II. *Machilus macrantha* (va), *Neolitsaea zeylanica* (a), *Homalium nepalense*, *Elaeocarpus pruniformis* (a), *Cedrela toona*, *Symplocos laurina* (f), *Syzygium cumini* (o), *Mallotus philippensis* (o).

IIa. *Cyathea spinulosa** (f), *Alsophila glabra* (la), *Phoenix humilis* (a).

III. *Memecylon edule* (f), *Glochidion valutinum* (la), *Gymnosporia baladiliana* (la).

IVa. *Pteridium aquilinum.*

V. *Gnetum scandens* (la), *Calamus latifolia* (a), *Clematis smilacifolia.* (MOONEY, 1942).

(ILLUSTRATIONS.—MOONEY, Loc. cit., Frontispiece and Plate 1).

ECOLOGICAL NOTE.—This is clearly not the climatic climax but probably includes many species that contributed to it. Fuller details and discussion are available in the reference given. Similar vegetation has also been recorded by MOONEY (1941) for ravines at 750-1,000 m. in the *Kalahandi Hills*, and (1944) for the *Pats of Ranchi*, *Palamau*, etc.

(iii) *Mt. Abu, Rajasthan.*—

An account of the vegetation has been published by MAHABALE and KHARADI (1946) from which it is evident that whatever it may have been originally, there is now no sub-tropical evergreen to be found though some of the higher valleys include *Syzygium cumini**, *Ixora arborea*, *Strobilanthes* spp. whilst the presence of numerous species of Himalayan origin also suggest subtropical conditions.

(iv) *Parasnath, Bihar* (SRIVASTAVA).—

Between 650 *and* 1,220 *m.*

I/II. *Litsea monopetala**, *Ficus retusa** et spp., *Symplocos racemosa*, *Machilus sericea.*

III. *Alangium*, *Linociera*, *Indigofera pulchella.*

V. *Vitis* spp., *Bauhinia anguina*, *B. vahlii*, *Jasminum strictum*, *Mezoneuron.*

Above 1,220 *m.* (*to* 1,360 *m.*)

I/II. Nil.

III. *Pittosporum floribundum*, *Grewia* sp., *Vangueria spinosa*, *Berberis asiatica*, *Reinwardtia.*

IVa. *Thalictrum*, *Polygala*, *Geranium*, *Lobelia.*

V. *Clematis* spp., *Bauhinia anguina.*

NOTE.—The steep slopes, shallow rocky soil and great exposure evidently perclude the development of the vegetation type usual at this elevation.

DEGRADATION STAGES OF SOUTHERN SUBTROPICAL BROADLEAVED HILL FORESTS

The subtropical forests of South India and the Western Ghats are mostly on steep hillsides with only occasional easier gradients which have mostly been cleared for cultivation at one time or other. The residual vegetation or regrowth has not been studied. Over the rest of the Peninsula, only hilltops are in question and especially where they are relatively flat, they have mostly been completely denuded of tree growth, heavily grazed and burnt, and are now grassland with only scattered fire resistant trees and patches of low forest or scrub in moister or sheltered spots. This residual vegetation is of little importance as forest, but references to literature concerning it are given in the Bibliography for convenience.

Sub-group 8B. Northern Subtropical Broadleaved Hill Forests

As there appear to be rather pronounced difference between the subtropical forests found on the lower slopes of the Himalayas and those on the hills south of the Brahmaputra two climax types are recognised. Both have been subject to shifting cultivation greatly affecting the vegetation, and in the adjoining Khasi hill ranges the broadleaved forest appears to have been extensively replaced by pine. It is possible that the pine was originally an edaphic preclimax restricted to well drained seasonally dry sites. For convenience it will be described under the next group but it is included here as a secondary seral stage developed after clearing and maintained by repeated clearing and burning.

SUBDIVISIONS

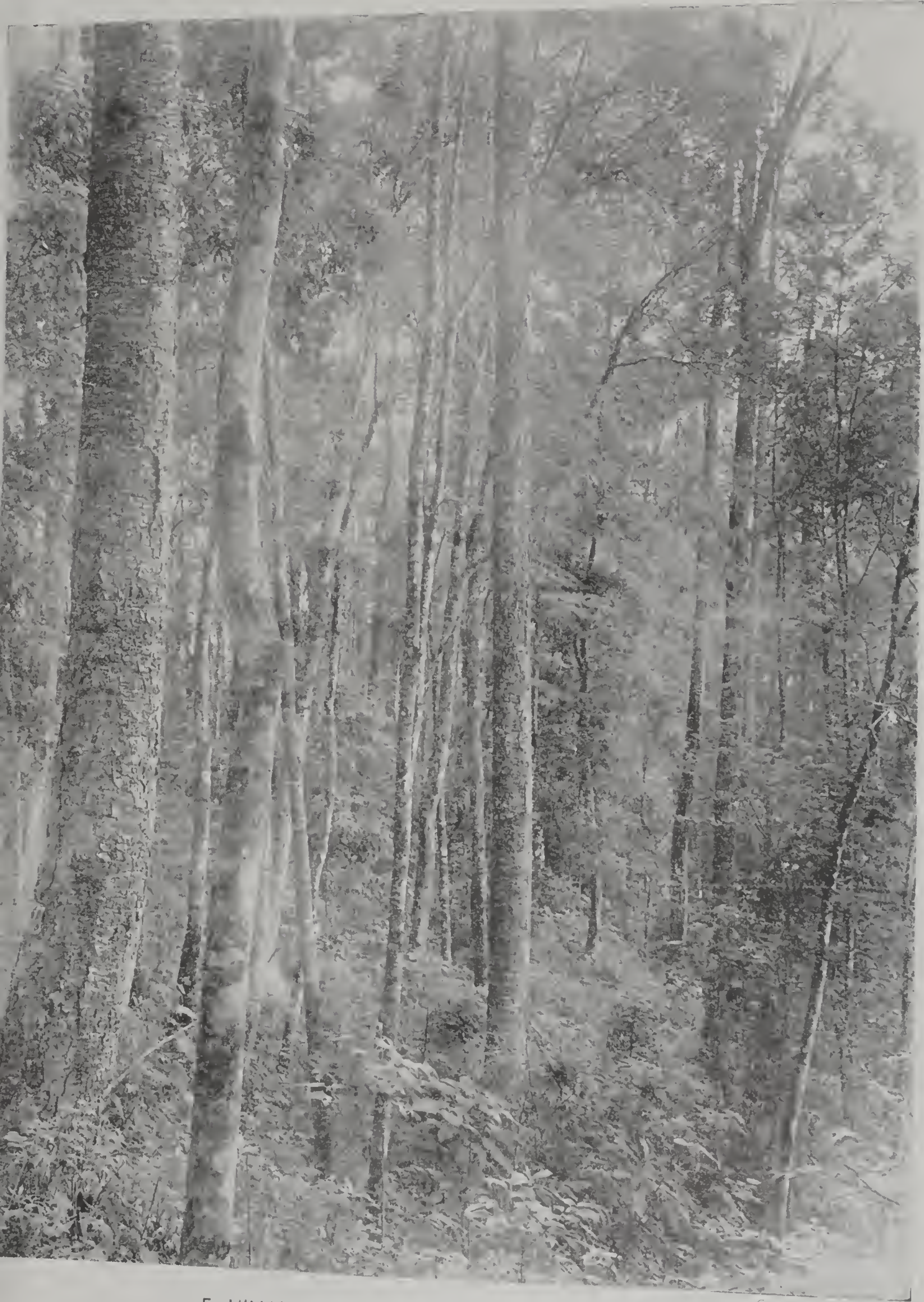
C1. East Himalayan subtropical wet hill forests.
C2. Khasi subtropical wet hill forests.
2S1. (Assam subtropical pine forest).
DS1. (Assam subtropical hill savannah woodland).

C1. East Himalayan subtropical wet hill forests

NOMENCLATURE.—

General	Tropical evergreen montane forest (SCHWEINFURTH).
Bengal	Lower hill forests (part). *Working Plans.* Middle hill forests (Working Plans). Subtropical or middle hill zone (COWAN.)
N. E. F. A.	Montane subtropical forest (BOR). Evergreen hill forests (part).

GENERAL DESCRIPTION.—Hill forests of good height and density, the dominant species being mostly evergreen though some large briefly deciduous trees occur, sometimes (e.g. *Betula*) in pure consociations. Under favourable conditions, 50 m. is attained and growth is very rapid, but on heavy soils and less favourable sites generally, 22-33 m. is more usual. The total canopy density is much less dense than in the tropical evergreen and the large trees rarely stand close together. A middle storey is generally recognisable composed of a variety of medium sized mainly evergreen tree species rarely reaching the top canopy. A shrubby undergrowth is always present and grass is absent though there is often a herbaceous layer. Bamboo may be present or not. Climbers are numerous



E. HIMALAYAN SUBTROPICAL WET HILL FOREST
A group of *Betula cylindrostachys* with mainly evergreen undergrowth.
Sim Reserve, Darjeeling Division, West Bengal.

H. G. Champion

and varied. Epiphytes are numerous, including shrubs and many orchids. Tree ferns occur locally. The precipitation is generally over 2,000 mm. The dry season with less than 50 mm. in the month is usually 5 months, November-March, and even during that period the humidity is fairly high owing to the montane situation.

DISTRIBUTION.—The lower slopes of the E. Himalaya from about 1,000 m. nearly upto 2,000 m.

LOCALITY FACTORS.—

Temperature.—The mean annual temperature ranges from 15° to 20°C, the mean temperature for January, from 10° to 16° C, the mean minimum for that month dropping to about 7°C indicating a definite cold season. The mean temperature for the hottest months is 23°C. The mean monthly temperature varies little during the months April to October.

Temperature (centigrade)

East Himalayan Subtropical Wet Hill Forests

Month	West Bengal KURSEONG 1,494 m.			West Bengal KALIMPONG 1,209 m.			Assam CHERRAPUNJI 1,303 m.			Assam AIJAL 1,097 m.		
	Mean	Mean max.	Mean min.	Mean	Mean max.	Mean min.	Mean	Mean max.	Mean min.	Mena	Mean max.	Mean min.
January . .	10·0	13·3	7·2	11·6	15·2	7·9	11·8	15·7	7·8	15·7	21·2	15·6
February .	12·2	14·4	7·8	12·7	16·3	9·1	13·0	16·8	9·2	15·2	20·6	9·8
March . .	15·6	19.4	11·7	16·7	20·8	12·6	16·6	20·4	12·7	21·1	26·4	15·8
April . .	17·8	21·7	14·4	19·3	23·4	15·3	18·4	21·8	14·9	22·1	26·6	17·4
May . .	19·4	22·8	16·1	20·4	23·7	17·1	19·2	22·3	16·1	21·4	25·6	17·2
June . .	20·0	22·8	17·8	21·6	24·0	19·1	20·1	22·2	17·9	22·7	25·9	19·6
July . .	20·6	23·3	18·3	21·8	24·1	19·6	20·4	22·4	18·5	22·8	25·9	19·7
August . .	20·6	22·8	18·3	21·9	24·2	19·6	20·5	22·5	18·5	22·2	25·0	19·4
September .	20·6	23·3	17·8	21·3	23·7	18·8	20·6	22·9	18·1	22·8	25·8	19·8
October . .	18·3	21·7	15.6	19·0	22·2	15·7	19·0	22·2	15·8	21·1	24·1	18·1
November .	15·0	18·9	11·7	15·6	19·3	11·9	16·0	19·7	12·2	19·3	23·3	15·4
December .	12·2	16·1	8·9	12·9	16.8	9·0	13·4	16·8	10·0	16·4	20·3	12·6
M. A. T. .	16·7	..	..	17·9	..	..	17·4	..	..	20·2	..	..
Annual mean maximum .	20·0	..	..	21·2	..	..	20·5	..	..	24·2	..	..
Highest record	..	..	..	30·6	..	..	30·6	..	..	..	..	..
Annual mean minimum .	13·8	..	..	14·6	..	..	14·2	..	..	16·7	..	..
Lowest record .	..	..	..	—0·6	..	..	0·6	..	..	?	..	..
No. of years .	..	..	..	20	..	..	35	..	..	?	..	..

Rainfall (millimetres)

East Himalayan Subtropical Wet Hill Forests

Month	Bengal KURSEONG 1,494 m.	Bengal KALIMPONG 1,209 m.	Assam CHERRAPUNJI 1,303 m.	Assam AIJAL 1,097 m.	Assam SHILLONG 1,500 m.
January	17	10	23	8	13
February	28	29	81	35	27
March	41	28	261	84	50
April	100	69	882	171	130
May	295	159	935	269	287
June	807	370	2,396	372	461
July	1,072	587	2,725	302	347
August	874	505	2,458	332	317
September	625	288	1,012	316	300
October	126	127	571	153	171
November	14	18	64	43	41
December	9	8	13	17	7
Total for year (M. A. R.)	4,044	2,189	11,422	2,101	2,150
Number of rainy days	132	104	162	124	122
Number of months with less than 50 mm.	5	5	2	4	4
M. A. Humidity	?	80	78	78	75
No. of years	58	15	12	48	35

Soil and Topography.—Very little has been recorded. The rocks forming the hills covered by the forest are mostly crystalline gneisses and granites, or metamorphic shales and schists. The soils are mostly brown earths

FLORISTICS.—The type is characterised by the prevalence of oaks and chestnuts, *Quercus* and *Castanopsis*, which are almost always present and often form an important part of the crop. Other temperate genera often seen are *Alnus*, *Prunus* and *Betula*. *Schima* (*Ternstroemiaceae*) is very characteristic of the type throughout its range though it also extends downwards into the tropical forest. A few *Dipterocarps* extend up to meet the type but are not usually mixed with it; thus *Shorea robusta* may be found, its presence being usually ascribable to edaphic peculiarities of the sites occupied. Pines are absent or confined to drier sandy soils or to well drained ridges. Differentiation of associations within the subtropical hill forest has been undertaken for North Bengal by COWAN. His four associations do not appear sufficiently different to call for separate treatment, his *Engelhardtia-Castanopsis-Schima-Betula hylium* being the principal one typical of the whole zone except for the absence of the *Engelhardtia* at the lower limit.

ILLUSTRATION.—Plate 69.

FLORISTICS.—

West Bengal—

(i) *Castanopsis-Schima forest, Kalimpong Division* (COWAN).—

I. *Castanopsis tribuloides** (37%), *C. indica** (13%), *Schima wallichii** (13%), *Terminalia bellerica* (3%), *Eugenia* spp. (2%), *Terminalia crenulata* (2%), *Albizzia procera* (2%).

II. *Boehmeria rugulosa* (4%), *Ficus cunia* (3%), *Heynea trijuga, Grewia vestita, Litsea monopetala, Eurya* spp.

NOTE.—This form extends down to 610 m. and is less evergreen than the following. It forms a transition from the Wet sal forest.

(ii) *Schima-Castanopsis-Phoebe forest, Kalimpong Division, West Bengal.* (COWAN).—

I. *Schima wallichii** (26%), *Castanopsis indica** (9%), *Phoebe attenuata** (5%), *Castanopsis tribuloides** (4½%), *Bauhinia purpurea* (4%), *Stereospermum personatum* (3%), *Phoebe lanceolata* (3%), *Michelia champaca* (2½%), *Cedrela* spp. (2%).

II. *Eurya* spp., *Macaranga* spp., *Turpinia pomifera, Machilus* spp., *Meliosma simplicifolia*, etc.

NOTE.—This form also extends down to 610 m. It is found with a higher rainfall than the last.

(iii) *Engelhardtia-Castanopsis-Schima-Betula forest, Kalimpong Division, West Bengal* (COWAN).—

I/II. *Castanopsis tribuloides** (16%), *Engelhardtia spicata** (15%), *Betula cylindrostachys** (11%), *Schima wallichii** (9%), *Alnus nepalensis* (8%), *Macropanax* and *Brassaiopsis* (3%), *Talauma hodgsoni* (2%), *Reevesia pubescens* (2%), *Cinnamomum* (2%), *Acer thomsoni* (1½%), *Cedrela* spp. (1½%), *Eurya* spp.

IIa. *Dendrocalamus sikkimensis.*

III. *Aechmanthera tomentosa, Lastrea dissecta, Masesa chisia.*

NOTE.—This example is from 1,220 to 1,520 m. At rather higher elevations, the *Engelhardtia* is more conspicuous and *Nyssa javanica, Alcimandra cathcartii, Machilus edulis* and other species appear.

(iv) *Ostodes association, Kalimpong Division, West Bengal.* (NOT SEEN).—

I. & II. *Ostodes peniculata** (11½%), *Machilus* spp. (8%), *Beilschmiedia* spp. (6%), *Lyonia ovalifolia* (5%), *Schima wallichii* (5%), *Engelhardtia spicata** (5%), *Terminalia chebula* (4%), *Aglaia perviridis* (4%), *Meliosma simplicifolia* (4%), *Cedrela febrifuga* (3%), *Betula* spp. (3%), *Eugenia kurzii* (3%).

NOTE.—This association occurs between 1,220 and 1,830 m. with heavy rainfall and is distinguished by the predominance of *Ostodes*. (COWAN).

(v) *Phoebe-Beilschmiedia-Engelhardtia hylium, Aka Hills, N.E.F.A.* (BOR). (NOT SEEN)—

I. *Phoebe paniculata**, *P. attenuata**, *Beilschmiedia roxburghiana**, *Engelhardtia**, *Nyssa javanica*, *Schima wallichii*, *Chinnamomum cecicodaphne*, *Morus laevigata*, *Syzygium cumini*, *Quercus fenestrata*, *Calophyllum polyanthum*, *Wightia*, etc.

II. *Drypetes venusta*, *Talauma hodgsoni*, *Gynocardia odorata*, *Nyssa javanica*, *Garcinia paniculata*, *Eugenia kurzii*.

IIa. *Dendrocalamus patellaris*, *Chimonobambusa griffithiana*.

III. *Daphne*, *Cyclea*, *Glycosmis*, *Strobilanthes* spp., *Phlogacanthus* etc.

IVa. *Impatiens* spp., *Araceae* spp., *Rauwolfia* spp., *Ainsliaea* etc.

IVb. *Oplismenus*.

V. *Vitis* spp., *Mucuna macrocarpa*, *Thunbergia coccinea*, *Calamus flagellum* (along streams).

(ILLUSTRATIONS.—BOR, loc. cit., Plates 4 & 5.)

(vi) *Aborland, N.E.F.A.*—BURKILL (1924) has described the vegetation of the Abor Hills at the eastern end of the range. He found no demarcation between the tropical and temperate forests. Considering primarily the floristics, he noted that the change from the tropics to the temperate genera and families occurs much lower than in Sikkim, by as much as 600 m. He does not list the typical species for each type recognised, but gives the altitudinal data for each species recorded.

(vii) *Manipur* (D.B. DEB)—

(a) *Langool Reserve. Quercus-Laurus-Schima hylium*, 800, to 1,000 m. or more.

I. *Lithocarpus spicatus**, *Q. vercus** (=*fenestrata*), *Q. serrata**, *Castanopsis*, *Schima*, *Cinnamomum*, *Saurauja* spp., *Litsea* spp., *Machilus*, *Syzygium*, *Cedrela toona*.

II/III. *Psychotria*, *Flacourtia*, *Symplocos*, *Crataeva nurvala*, *Emblica*.

V. *Clematis* spp., *Cudrania*, *Entada*, *Porana*, *Rubus* etc.

(b) *Ukhrul and Shugnu. Pinus-Quercus hylium*, 1,200 to 1,500 m., 1,750 mm. rainfall, volacanic rock.

I. *Pinus insularis* (*khasya*)* dominant,

II. *Quercus* spp.*, *Lithocarpus**, *Schima*, *Castanopsis* spp., *Betula alnoides*, *Acer oblongum*, *Engelhardtia*, *Symplocos*.

III. *Pittosporum* sp., *Myrsine*, *Debregeasia*, *Rubus* spp., etc.

V. *Rosa*, *Cissus*, *Piper*.

Epi. Orchids numerous.

(c) *Koupru and Maohing. Saurauja-Phoebe-Beilschmiedia hylium*, 900 to 1,800 m., 3,000 to 4,000 mm. rainfall.

I/II *Saurauja** (3 spp)., *Phoebe lanceolata**, *Beilschmiedia**, *Cinnamomum cecicodaphne*, *Schima*, *Lauraceae* (many spp.), *Ostodes*.

III. Abundant shrub layer.

V. Conspicuous with *Entada*, *Mucuna*, *Cissus*, *Porana* etc.

Epiphytes many and varied; orchids, ferns and mosses.

C2. Khasi subtropical wet hill forests

NOMENCLATURE.—*Manipur—Tripura*—Montane subtropical forests (DEB).

Assam.—(Shillong plateau) Evergreen forest (BOR).

DESCRIPTION.—Dense evergreen forest of no great height, rarely exceeding 20 m., the dominant stems with smooth cylindrical boles and rather branchy crowns. A second storey is hardly distinguishable and the amount of shrubby undergrowth varies considerably with the density of the upper canopy. There is a heavy growth of epiphytic mosses, ferns and phanerogams.

DISTRIBUTION.—The upper slopes of the Khasi, Jaintia and adjacent hills including the tops where they have not been denuded.

LOCALITY FACTORS.—

Temperature.—The range of the monthly means is between 50° and 70°C the cool season being fairly well marked, frost being sometimes experienced. Data are given for Shillong and Cherrapunji.

Rainfall.—Typically over 70 mm. and commonly over 100 mm., with exceptionally high figures locally as at Cherrapunji with 10,800 mm. Data are given for Shillong, Cherrapunji, Imphal, Manipur, Kohima (Naga Hills) and Aijal (Lushai Hills).

The marked difference between the vegetation of this and the previous type would appear to be largely due to the difference between exposed hill top sites, and the flanks of a great mountain range.

FLORISTICS.—

(i) *Shillong Plateau, Assam* (cf. BOR). 1,300 m.—

I. *Quercus* spp.*, *Manglietia insignis*, *Beilschmiedia**, *Cinnamomum* spp., *Machilus* spp., *Schima khasiana*, *Bucklandia*, *Ficus nemoralis*.

II. *Lindera* spp., *Ilex* spp., *Ligustrum* spp., *Litsea* spp., *Prunus* spp., *Pyrus* spp., *Symplocos* spp., *Myrica sapida*, *Lyonia* spp.

IIa. *Chimonobambusa callosa*.

III. *Myrsine semiserrata*, *Daphne* spp., *Euonymus* spp., *Hypericum* spp., *Viburnum* spp., *Zanthoxylum* spp., *Rosa* spp., *Rubus* spp.

IV. *Elaeagnus*, *Hedera*, *Lonicera*, *Smilax*, *Vitis*, etc.

NOTE.—The richness of the flora is remarkable as also the mixture of temperate and tropical genera. Apparently there are no tree ferns.

(ii) *Manipur* (*Koupru and Maohing*). NOT SEEN.

Saurauja-Phoebe-Beilschmiedia hylium (DEB).—

I. *Saurauja* spp.*, *Beilschmiedia* spp.*, *Schima wallichii*, *Cinnamomum* spp., *Litsea* spp., *Machilus* spp., *Ostodes*, *Quercus truncata*, *Castanopsis tribuloides*.

II. *Dalbergia* spp., *Pavetta indica*, *Micromelum pubescens*.

III. *Eurya japonica*, *Daphne cannabina*, *Psychotria* spp., *Rubus*, *Leea crispa*, *Strobilanthes* spp.

IV. *Entada phaseoloides*, *Thumbergia*, *Smilax*, *Mucuna*, *Cissus* etc.

Quercus-Engelhardtia-Schima-Vaccinium hylium (DEB).—

I. *Quercus griffithii**, *Engelhardtia**, *Q. semiserrata*, *Schima wallichii**, *Vaccinium donianum**, *Quercus* spp.

II. *Wendlandia* spp., *Morinda angustifolia*.

III. *Rosa xanthocarpa*, *Gouania*, *Paederia*, *Uncaria*.

SERAL AND DEGRADED TYPES OF NORTHERN SUBTROPICAL BROADLEAVED WET HILL FORESTS

In many parts of the Khasi and adjoining hills, repeated shifting cultivation with felling and burning, have cleared and greatly altered the original forest cover presumed to have been of broadleaved evergreens with or without pines. There are now considerable areas of open grassland with scattered trees adjoining pine forest or broadleaved forest (locally in N. Cachar, almost pure oak), and also, notably on the Naga Hills, treeless grassy hill tops. These occurrences may accordingly be viewed as degradation stages of the climatic climax.

2S1. (Assam subtropical pine forest)

This pine forest is described under Group 9 below (p. 274) in view of its close resemblance to the Himalayan subtropical pine forests and its possible climax status.

DS1. (Assam subtropical hill savannah woodland)

Where the secondary growth after clearing has included an adequate stocking of pine seedlings and the broadleaved species have eliminated by burning, more or less pure pine forest results as a secondary sere stabilised by fire.

GROUP 9. SUBTROPICAL PINE FORESTS

1. NOMENCLATURE

Punjab	Chil forest.
Uttar Pradesh	Chir forest.
Assam	Pine forest.

2. GENERAL DESCRIPTION

Typically a practically pure association of pine (*roxburghii*), but very generally considerably influenced by the annual or periodic fires which take place. Typically no other trees now occur in the top canopy, there is practically no underwood and even shrubs are few, but where moisture conditions are a little more favourable there tends to be an underwood of broad-leaved trees. These trees are mostly evergreen oaks, and increase with rising altitude leaving the pine on the warmer, drier ridges and ultimately as scattered standards. Towards the lower limit there is a corresponding increase of the trees of the dry deciduous type. A grass soil cover is usual with a number of bulbous and annual herbs which flower in the rainy season. Climbers and bamboos are absent.

3. DISTRIBUTION

Forests of *Pinus roxburghii* are found throughout the whole length of the Western and Central Himalayas from the N.W. Frontier to Sikkim and West Bhutan between 1,000 m. and 1,800 m. extending on ridges down to 600 m., and upto 2,300 m. on southern exposure. The absence of this pine forest from Kashmir is noteworthy and related to the weakened S.W. monsoon.

In the Khasi, Naga and Manipur hills, forest of *Pinus insularis* (*P. khasya*) occurs at similar altitudes.

4. LOCALITY FACTORS

Temperature.—The mean annual temperature lies between about 15° and 20° C. The data for Kathmandu (Nepal) are given as indicative of conditions in the east of the range.

Temperature (centigrade)

Sub-tropical Pine Forests

Month	Punjab DHARAMSALA 1,311 m.			Uttar Pradesh RANIKHET 1,850 m.			Nepal KATHMANDU 1,338 m.			Assam SHILLONG 1,500 m.		
	Mean	Mean max.	Mean min.	Mean	Mean max.	Mean min.	Mean	Mean max.	Mean min.	Mean	Mean max.	Mean min.
January . .	10·2	13·9	6·4	7·8	12·8	5·6	10·2	18·1	2·3	9·7	15·6	3·8
February .	12·8	17·2	8·4	8·9	12·8	4·4	12·3	20·1	4·4	11·4	16·9	5·8
March . .	18·4	22·3	14·4	13·9	18·3	9·4	16·3	25·2	7·4	15·9	21·3	10·4
April . .	19·9	24·6	15·2	18·3	22·8	13·3	20·1	28·8	11·4	18·7	23·4	13·9
May . .	23·6	28·1	19·1	20·0	24·4	15·9	22·7	29·6	15·8	19·2	23·3	15·1
June . .	28·1	32·9	23·3	21·7	25·6	17·8	24·3	29·3	19·3	20·4	23·6	17·2
July . .	23·8	27·0	20·7	20·0	23·3	17·2	24·6	28·7	20·4	21·1	24·1	18·1
August . .	22·8	25·4	20·2	19·4	22·8	16·7	24·4	28·6	20·2	20·9	23·9	17·8
September .	22·4	25·5	19·2	18·9	22·8	16·1	23·4	28·1	18·7	20·0	23·5	16·4
October .	18·7	22·7	14·7	16·1	20·6	12·2	20·2	26·7	13·6	17·2	21·7	12·7
November .	15·8	20·6	10·9	12·8	16·7	8·3	15·2	22·7	7·6	12·5	18·9	6·1
December .	11·5	15·5	7·4	9·4	13·9	6·1	11·0	18·8	3·2	10·4	16·4	4·4
M. A. T. .	19·0	..	..	15·6	..	..	18·7	..	..	16·5	..	..
Annual mean maximum .	23·0	..	..	19·7	..	..	25·4	..	..	21·1	..	..
Highest record .	?	..	..	30·0	..	..	37·2	..	..	32·2	..	..
Annual mean minimum .	15·0	..	..	11·1	..	..	12·0	..	..	11·9	..	..
Lowest record .	?	..	..	—1·1	..	..	—2·8	..	..	—2·8	..	..
No. of years .	?	..	..	?	..	..	40	..	..	35	..	..

Rainfall.—The rainfall is very largely derived from the S. W. monsoon falling in the summer months, though to the N. W. there is an increasing proportion of winter precipitation. The Khasi hills have a much higher rainfall but the ecological status of the forest is in question, *vide* p. 275.

Rainfall (millimetres)

Sub-tropical Pine Forests

Month	Punjab DHARAMSALA 1,311 m.	Punjab KOTKHAI 1,615 m.	U. P. PAURI 1,676 m.	U. P. ALMORA 1,615 m.	Assam SHILLONG 1,500 m.	Nepal KATHMANDU 1,338 m.	Manipur UKHRUL 1,859 m.
January	117	62	62	48	13	10	14
February	115	81	69	48	27	42	49
March	91	69	54	44	50	15	55
April	53	56	30	26	130	26	91
May	57	65	57	52	287	130	175
June	237	103	134	147	461	246	312
July	936	226	345	264	347	373	321
August	972	212	341	241	317	347	283
September	298	107	138	132	300	182	192
October	29	21	31	34	171	37	128
November	13	11	8	7	41	2	70
December	51	25	25	19	7	8	12
Total for year (M.A.T.)	2,966	1,039	1,295	1,061	2,150	1,417	1,752
No. of rainy days	97	67	75	69	122	99	119
No. of months with less than 50 mm.	2	3	4	7	4	7	3
M. A. Humidity	?	?	?	?	75	76	?
No. of years	75	75	77	77	35	6	19

5. GENERAL FLORISTICS

The pine predominates over everything else and creates an environment inimical to most broadleaved trees. *Quercus* is the most typical broadleaved associated genus with *Rhododendron* and *Lyonia* (from higher altitudes) and *Syzygium cumini*, *Mallotus* and *Carissa* (from lower altitudes), *Rhus*, *Berberis* and *Rubus* are representative shrubs and one or two species of *Ficus* are present. *Chrysopogon* and *Heteropogon* with *Themeda* and *Arundinella* are the prominent grass genera.

6: SUBDIVISIONS

The main tract of pine forest in which there are virtually no other top canopy species is rather sharply differentiated at the upper limit with a restricted transition to oak forest. At the lower altitudes, however, there is a much more intimate mingling with the deciduous trees of the tropical mixed deciduous forests, dominance appearing to be related mainly to topographically conditioned micro-climatic variation. Whereas with fire protection the pine higher up loses ground to the broadleaved trees, in this lower zone it is the pine that spreads. As moreover forest management tends to be different in the two cases, it has been thought desirable to recognize a subtype for the lower zone. The types to be described are accordingly :

C1. Himalayan subtropical pine forests.
DS1. Himalayan subtropical scrub.
DS2. Subtropical Euphorbia scrub.
C2. Assam subtropical pine forest.
DS1. Assam subtropical pine savannah.

C1. Himalayan subtropical pine forests

C1a. Lower or Siwalik chir pine forest

NOMENCLATURE.—

General . . .	*Pinus roxburghii* forest (part). (SCHWEINFURTH).
Punjab . . .	*Lower or unstable*, together with *middle or intermediate zone, pine forest* (MOHAN).

DESCRIPTION.—The pine stands singly or in groups with a scattered lower deciduous tree storey more numerous in depressions and cool aspects. There is usually a fairly continuous low scrub growth of xerophytic shrubs.

DISTRIBUTION.—General at appropriate altitudes on the Siwalik Hills from Jammu to Uttar Pradesh.

LOCALITY FACTORS.—Typically on steep dry slopes below 1,000 m. on the Siwalik conglomerates and sandstones. Detailed information is available from PURI and MOHAN (1956).

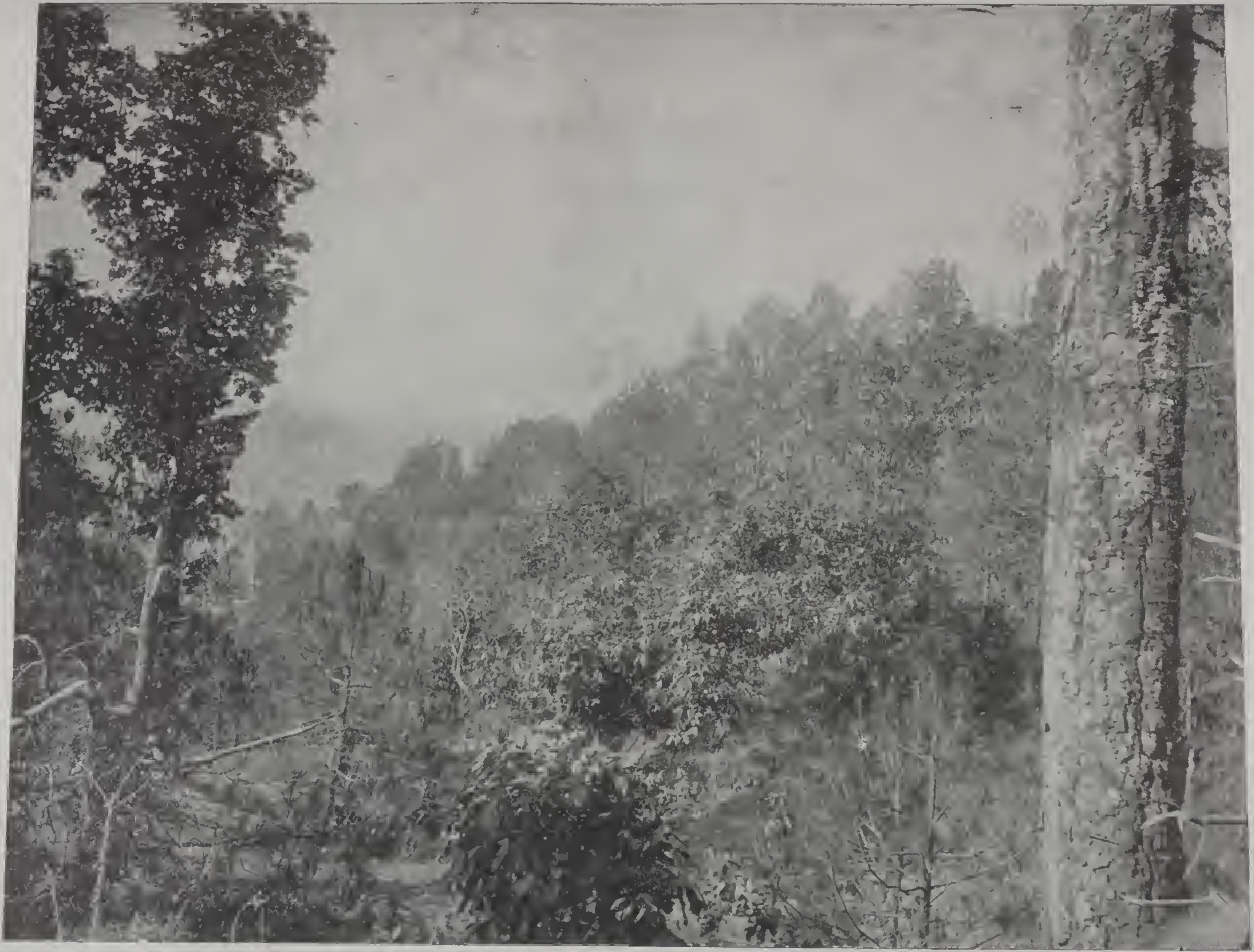
ILLUSTRATION.—Plate 70.

FLORISTICS.—

(i) *Kangra, Punjab.*—

I. *Pinus roxburghii**.

II. *Terminalia chebula, Mallotus philippensis, Pyrus pashia, Syzygium cumini, Albizzia chinensis, Emblica, Acacia catechu.*



SIWALIK CHIR PINE FOREST

Pinus roxburghii and *Shorea robusta* growing together with stragglers such as *Quercus incana* from temperate zone. Transition form. 1100 m. Lansdowne, Uttar Pradesh.

Basti Ram

III. *Carissa opaca*, Dodonaea viscosa, Rubus ellipticus, Crataegus crenulata, Flacourtia, Myrsine africana, Woodfordia fruticosa, Colebrookia, Berberis, Indigofera pulchella, Murraya koenigii.*

IVb. *Chrysopogon fulvus, Cymbopogon* spp., *Dichanthium annulatum, Heteropogon contortus, Themeda anathera.*

V. Very few. *Rosa moschata.*

NOTE.—In moister sites, *Quercus incana, Q. glauca, Pyrus, Rhododendron* etc.

(ii) *Kalagarh Division, Uttar Pradesh* (Preservation Plot No. 7, 500 m.) (% of trees over 20 cm. dbh.)—

I. & II. *Shorea robusta* (60%), *Terminalia tomentosa* (15%), *Pinus roxburghii* (8%), *Anogeissus latifolia* (8%), *Ougeinia oojeinensis* (3%), *Acacia catechu* (2%), *Syzygium cumini* (1%), *Lagerstroemia parviflora, Lannea coromandelica, Albizzia* sp., *Terminalia bellerica, T. chebula, Cassia fistula* (all together 3%).

NOTE.—This plot is in the lower part of the transition zone Siwalik sal/Siwalik chir. In many such localities the proportion of chir is gradually increasing as a result of fire protection, so much so that in places, especially in the upper parts, almost pure chir crops have become established.

GENERAL NOTE.—MOHAN and PURI (1956) differentiate six sub-types:

(1) Chir-*Carissa*-grass with *Terminalia chebula, Lannea*, etc.

(2) Chir-*Carissa-Indigofera*-grass with abundant pine regeneration.

(3) Chir-*Quercus incana* with *Berberis, Myrsine* and grass.

(4) Chir-*Acacia catechu* and grass with *Mallotus, Lannea* etc. This type is difficult for pine regeneration.

(5) Chir-*Wendlandia-Dodonaea-Carissa.*

(6) Chir-*Carissa-Flacourtia* grass—pine regeneration scarce.

DUDGEON and KENOYER differed from most earlier workers in allotting to the pine only the status of a xerophytic edaphic climax in a broadleaved sclerophyll formation. This view has been supported by PARKER, MOHAN and PURI and others, but is not acceptable to the present authors who consider that there is a definite altitudinal zone lying between about 1,200 and 1,800 m. on southern exposures, and rather lower upper limit on northern slopes, naturally varying with micro-relief, in which the pine forest should be accorded climatic climax status. The authors cited above suggested that the distribution of these forms appears to be primarily related to site variation, and that the pine "is scarcely a stable community ……except for some special habitats like quartzite formations, scarp slopes (and) schists". They accept that it is, in fact, stable on such sites, and as these comprise a considerable proportion of the whole area, it is thought preferable to accept the pine as a natural climax community which has been widely extended by biotic influences.

C1b. Upper or Himalayan chir pine forest

NOMENCLATURE.—

General . . .	*Pinus roxburghii* forest (part) (SCHWEINFURTH) U. P. Chir forest. Punjab Chil forest.

DESCRIPTION.—High forest 20-35 m. high usually forming a canopy from one-third to two-thirds complete and in any case light. As a rule no other trees reach the top canopy and there are only scattered trees representing a second storey. The annual fires prevent the development of the shrubs which would otherwise form an undergrowth, as they do on steep and rocky ground and at lower elevations generally, and on sites which escape fire. During the monsoon a rich grass growth develops, which dries up and is flattened down in the winter and from then till the rains, the soil appears completely bare of vegetation and is covered with the fallen needles till they get burnt and a flush of new grass appears.

DISTRIBUTION.—The Himalayas from Bhutan westwards, from 1,200 to 1,800m. overlapping the tropical deciduous forest at the lower elevations notably on the Siwalik hills, and giving way to the temperate forests (broadleaved or coniferous) above. Extensively developed in Jammu, Himachal Pradesh, Punjab and Uttar Pradesh, *P. roxburghii* extends eastwards through Nepal, and outliers occur in Darjeeling district where it is found in intimate mixture with *Shorea robusta*. The absence of the type on exposed southern aspects of the outer ranges of the Himalaya is noteworthy and is perhaps primarily conditioned by the combination of excessive heat with high humidity in the monsoon period, unfavourable to seedling regeneration of the pine.

LOCALITY FACTORS.—The climatic data given on pp. 268-269 are fairly representative, but the type occurs under a wide range of conditions with rainfall from about 900 mm., upto over 2,500 mm. (Dharmsala, Palampur) and with temperatures running very high during the dry summer months. Snow falls most years in the upper parts of the pine forests but rarely lies for more than a few days. A locality factor of the greatest significance is fire, for until the introduction of forest management all these forests were burnt at frequent intervals, practically annually, and the distribution and composition of the type has been greatly influenced by this as will be discussed later.

Pine forest is very rarely found on level ground as only in a few such places has it escaped clearing for cultivation. Apparently most of the more easily sloping ground has been cleared at one time or another for temporary cultivation, but the pine is the most efficient colonizer when the fields are abandoned. The forests are mostly heavily grazed.

ILLUSTRATION.—Plate 71.

FLORISTICS.—

(i) *Maharpali, Almora Distt., U. P.* 1,500 m.—

I. *Pinus roxburghii.**

HIMALAYAN CHIR PINE FOREST

Pinus roxburghii forest burnt annually and then being regenerated with fire protection. Distant higher hills carry *Quercus incana* and *Q. dilatata* forests. Parkot, Almora, Uttar Pradesh. H. G. Champion

II. *Ficus roxburghii** (o), *Syzygium cumini* (r), *Engelhardtia colebrookiana* (r), *Lyonia ovalifolia** (o), *Quercus incana* (o), *Rhododendron arboreum** (lf), *Symplocos crataegoides*, *Myrica sapida* (r).

III. *Indigofera dosua* (f), *Flemingia fruticulosa* (f), *Lespedeza sericea* (o), *Rubus ellipticus* (o), *Viburnum coriaceum* (o), *Glochidion velutinum* (lf), *Leptodermis lanceolata* (lo), *Aechmanthera tomentosa* (lo).

IVa. *Teucrium quadrifarium* (o), *Pedicularis carnosa* (f), *Pouzolzia hirta* (f), *Anaphalis araneosa* (f), *Erigeron multicaulis* (lo), *Euphorbia prolifera* (f), *Swertia* sp. (o), *Habenaria suzannae* (r).

IVb. *Heteropogon contortus* (o), *Arundinella intricata* (a), *Eulalia hirtifolia* (f), *Bothriochloa pertusa* (f), (*Capillipedium assimile*) (lf), *Sehima notata* (f), *Themeda anathera* (o), *Arundinella bengalensis* (o), *Carex condensata* (o).

V. There are no climbers.

NOTE.—This area was heavily grazed and occasionally burnt prior to enclosure and protection during the past 5 years. There was a complete dense grass cover, practically none of the shrubs being visible through it.

(ii) *Kaligad, Almora Distt., U. P.* 1,830 m.—

I. *Pinus roxburghii**.

II. *Quercus incana* (a), *Lyonia ovalifolia** (a), *Rhododendron arboreum** (o), *Pyrus pashia* (o), *Myrica rubra* (f), *Crataegus crenulata* (f), *Symplocos crataegoides* (i), *Coriaria nepalensis* (o).

III. *Indigofera dosua* (f), *Myrsine africana* (f), *Inula cappa* (f), *Leptodermis lanceolata* (f), *Berberis lycium* (a), *Rubus ellipticus* (f), *R. lasiocarpus* (o), *Moghania fruticulosa* (a), *Viburnum cotinifolium*.

IVa. *Plectranthus strictus* (a), *Anaphalis* sp. (f), *Rosocea* (f), *Gallium* sp. (f), *Artemisia vulgaris* (o), *Desmodium parvifolium* (o).

IVb. *Eulalia mollis* (f), *Arundinella intricata* (f), *Agrostis alba* (f), *Capillipedium parviflorum* (o), *Sporobolus elongatus* (o), *Heteropogon contortus* (r).

V. *Rosa moschata* (p).

NOTE.—Protected for many years except for light grazing, shrub growth well developed and grass growth correspondingly slight.

GENERAL NOTE.—This type of forest has been studied and described as much as any in India. Descriptions of representative occurrences throughout the range of the type are given by TROUP (1931) (pp. 1038-1045), who devotes 48 pages to it collecting the information available upto 1920. Many working plans for the Punjab, H. P., U. P. and Jammu describe local forms and discuss the ecological aspects at considerable length. OSMASTON (1922), KENOYER (1921), and DUDGEON and KENOYER (1924), have published ecological papers dealing with the pine forests and the adjoining types, and the senior author has contributed articles on the effects of fire (1919), on "The interaction between *Pinus roxburghii* and its habitat" (1923), and on the "Influence of the hand of man on the distribution of forest types" (1923). A useful paper on the "Ecology of *Pinus roxburghii* in Kangra and Hoshiarpur forest divisions" was also published in 1933 by MOHAN.

The type regenerates itself directly on abandoned clearings though slow to do so if the soil has become badly aerated. It also regenerates on landslips and new gravelly alluvium. It is more fire hardy than any of its competitors and itself produces conditions increasing the fire risk. Fire protection has resulted in a downward extension into the deciduous forest and a retrogression at the higher elevations and in sheltered sites. The relation to the more mesophytic *Pinus wallichiana* association is interesting and is described by TROUP and others.

DS1. Himalayan subtropical scrub

Over considerable areas in the Siwalik chir zone, extending up into the Himalayan chir forest and down into the mixed deciduous forests, the overwood has been destroyed or perhaps has been unable to develop owing to excessively dry and shallow soil, and open shrub formations occupy the ground. The dominant species vary a good deal and often one or two of them may so predominate as to give a characteristic appearance. MOHAN and PURI (1956) in differentiating six subtypes of the Siwalik chir, describe the associated shrub species for each. Probably the residual scrub on degradation will show its origin but both edaphic and biotic factors are involved in determining what persists. *Carissa, Dodonaea* and *Rhus parviflora* scrub may be mentioned as examples.

DS2. Subtropical Euphorbia scrub

Euphorbia royleana forms consociations sometimes of considerable extent. Their distribution is related to edaphic factors, notably dry rocky ridges, but under biotic pressure they extend and become denser and purer owing to the elimination of less resistant species.

ILLUSTRATION.—Plate 72.

C2. Assam subtropical pine forest

NOMENCLATURE.—

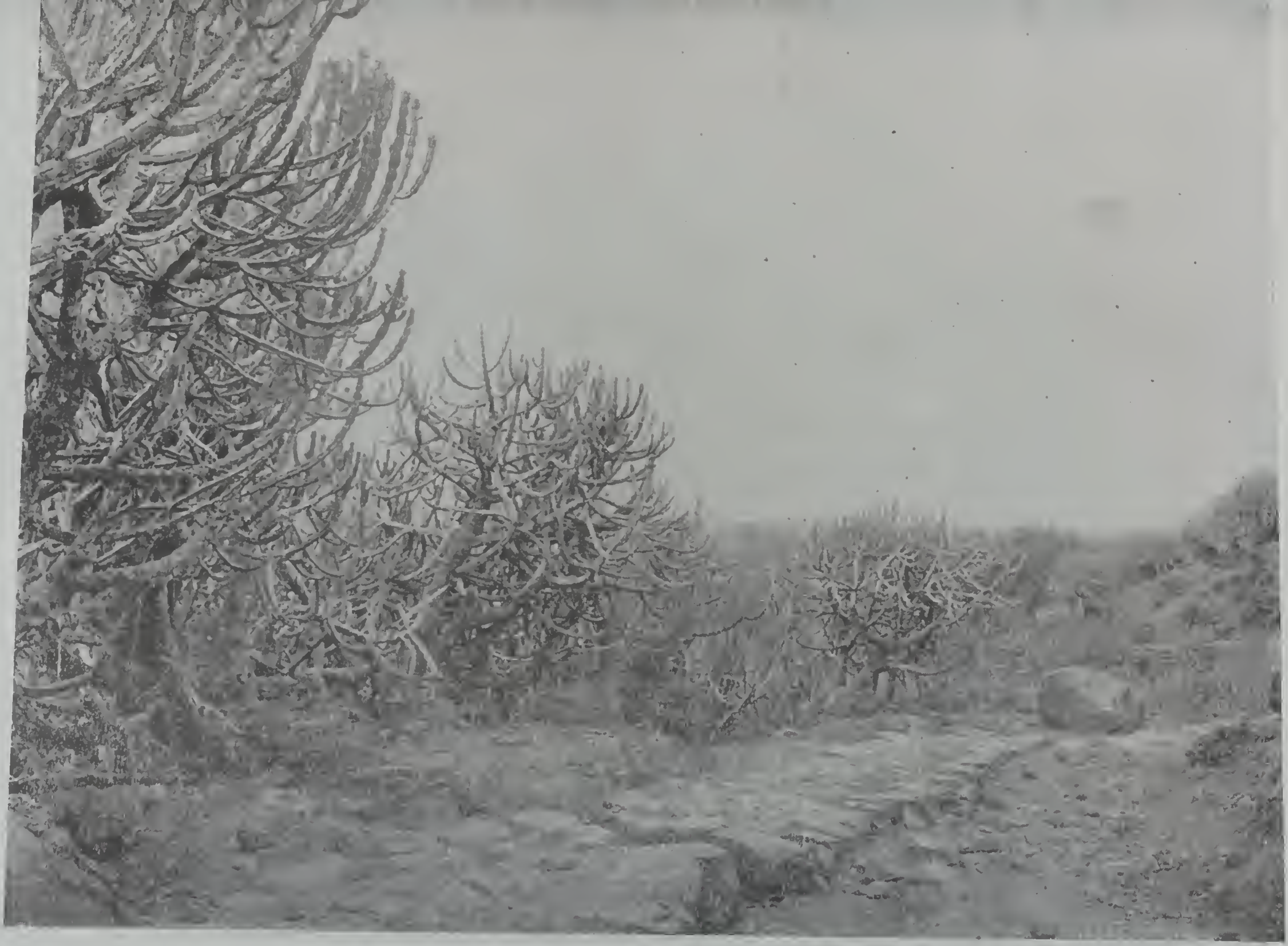
General . . . Steppe forest (*P. khasya*). SCHWEINFURTH.

DESCRIPTION.—Very similar to the Himalayan pine forests, the occurrence of fire reacting in a similar way on the vegetation.

DISTRIBUTION.—Forests of *Pinus insularis* (*khasya*) are found in the Khasi and Naga hills, and in Manipur.

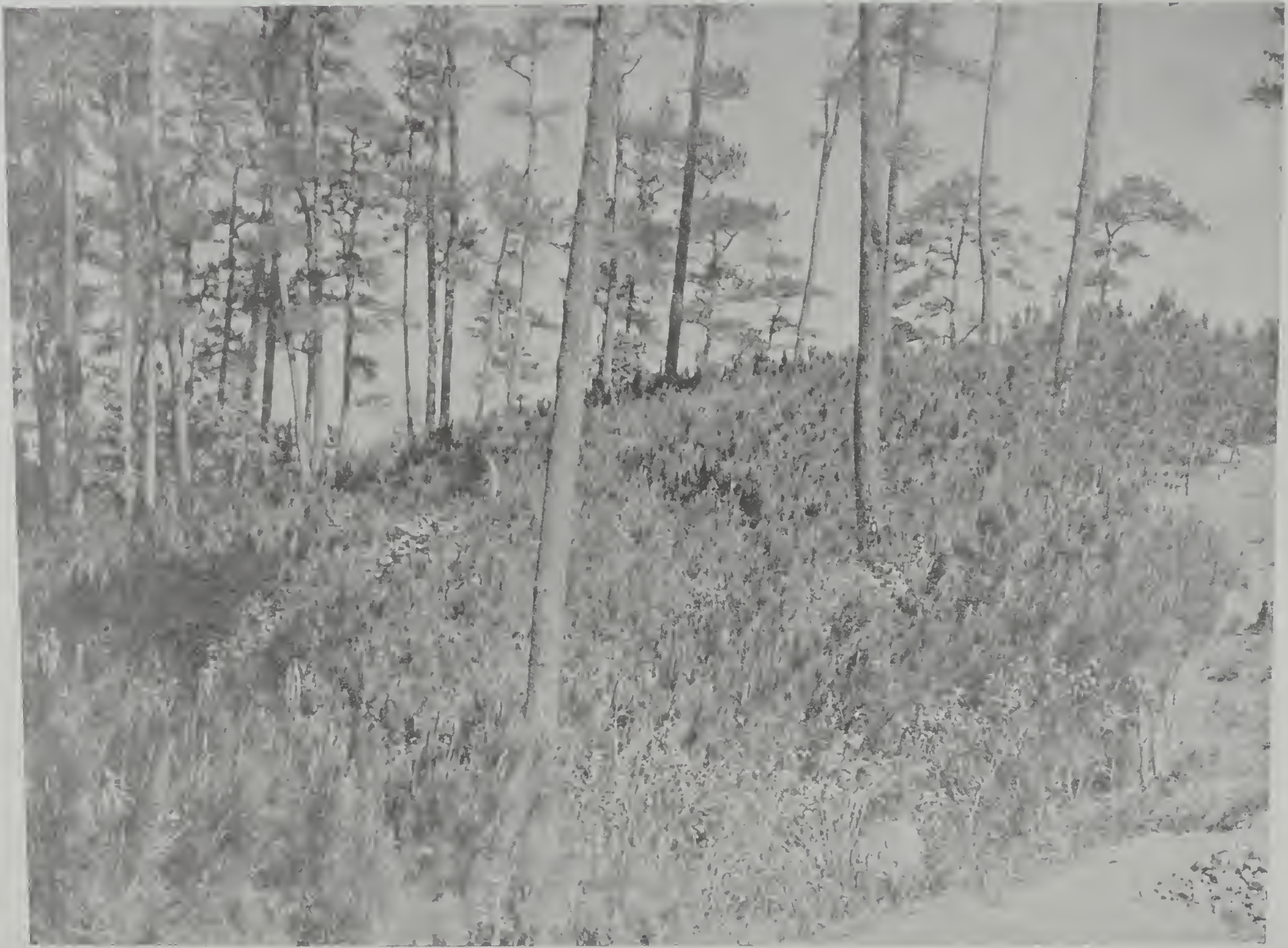
LOCALITY FACTORS.—The type occurs between 800 and 1,600 m. The climatic data for Shillong may be taken as representative, the optimum conditions for the type being apparently at slightly lower elevations. Rainfall is usually over 1,800 mm.

Siliceous rocks predominate with gneiss, schist and limestone on the Shillong plateau and volcanic rocks in Manipur. Well drained soil is essential and it is usually sandy, though near Shillong a reddish clay carries good pine woods.



SUBTROPICAL EUPHORBIA SCRUB

Euphorbia royleana association with some *Carissa spinarum* on an exposed slope in chir pine belt at 1300 m. Kangra valley, Punjab. R. S. Troup



ASSAM SUBTROPICAL PINE FOREST

Mature *Pinus insularis (khasya)* with standards retained and sowings underneath in strips. Raiwat Chaun, Shillong, Assam.

H. G. Champion

ILLUSTRATION.—Plate 73.

FLORISTICS.—

(i) *Khasi Hills, Assam.*—

I. *Pinus insularis**.

II. *Quercus griffithii, Q. fenestrata, Acer oblongum, Magnolia campbellii, Lindera latifolia, Prunus acuminata, P. nepalensis, Schima wallichii, Myrica sapida, Rhus succedanea, R. griffithii, R. semialata, Docynia indica, Lyonia ovalifolia.*

III. *Rubus lasiocarpus, R. rubra, R. paniculatus, R. moluccanus, Viburnum foetidum, V. coriaceum, Myrsine semiserrata, Osbeckia crinita, Desmodium* spp.

NOTE.—Many genera and species are the same as found in the *Pinus roxburghii* forests, but the general facies is more mesophytic. *Betula alnoides* forms consociations of considerable extent. (BOR).

(ii) *Manipur.* (DEB) (NOT SEEN)—

I. *Pinus insularis**.

II. *Quercus griffithii, Quercus serrata, Quercus* spp., *Castanopsis* spp., *Betula alnoides, Acer oblongum, Schima wallichii, Rhus* spp., *Salix tetrasperma, Engelhardtia spicata, Lyonia ovalifolia, Rhododendron arboreum.*

III. *Eurya, Pittosporum, Photinia, Myrsine, Viburnum, Rubus, Indigofera,* etc.

IVb. *Agrostis, Brachypodium sylvaticum,* etc.

V. *Rosa assamensis, Cissus, Piper,* etc.

NOTE.—DEB describes these forests as the climax unit of his montane subtropical *Pinus-Quercus* formation though mentioning that it is greatly affected by anthropogenic influences.

DS1. Assam subtropical pine savannah

The pine occurs as scattered trees over grass, obviously as a result of biotic pressure.

GROUP 10. SUBTROPICAL DRY EVERGREEN FORESTS

1. NOMENCLATURE

General . . .	Subtropical evergreen dry broadleaved forest (SCHWEINFURTH).
Jammu . . .	Subtropical broadleaved forest.
Punjab . . .	Olive forest. *Acacia modesta* (*phulai*) forest.

2. GENERAL DESCRIPTION

Low practically scrub forest of small-leaved evergreen trees and shrubs including thorny species; the latter become more prevalent on hot dry exposures and form a transition to northern thorn forest. Shrubby growth predominates but there is a monsoon development of herbs including grass.

3. DISTRIBUTION

The Bhabar, the Siwalik hills and the foothills of the Western Himalayas, extending up the main valleys to about 1,000 m.

4. LOCALITY FACTORS

The climate of Hoshiarpur (Punjab) at 322 m. and Mirpur (Jammu) at 366 m. may be taken as representative. It is characterised by a long hot and very dry season and a cold winter with occasional frost.

Rainfall.—The annual precipitation rarely exceeds 1,000 mm. but is usually over 500 mm. occurring mostly in July-August but with a fair proportion of winter rains.

Soil and Topography.—On hilly ground, mostly on sedimentary rocks, sandstone, shales, marls and limestone. The soil is usually shallow and dry. From 300 m. up to as much as 1,500 m.

5. SUBDIVISIONS

The following types are described :

C1. Subtropical dry evergreen forest.
DS1. Dodonaea scrub.

C1. Subtropical dry evergreen forest

SUBDIVISIONS—

Two subtypes are distinguished.

1a. Olea cuspidata scrub forest.
1b. Acacia modesta scrub forest.

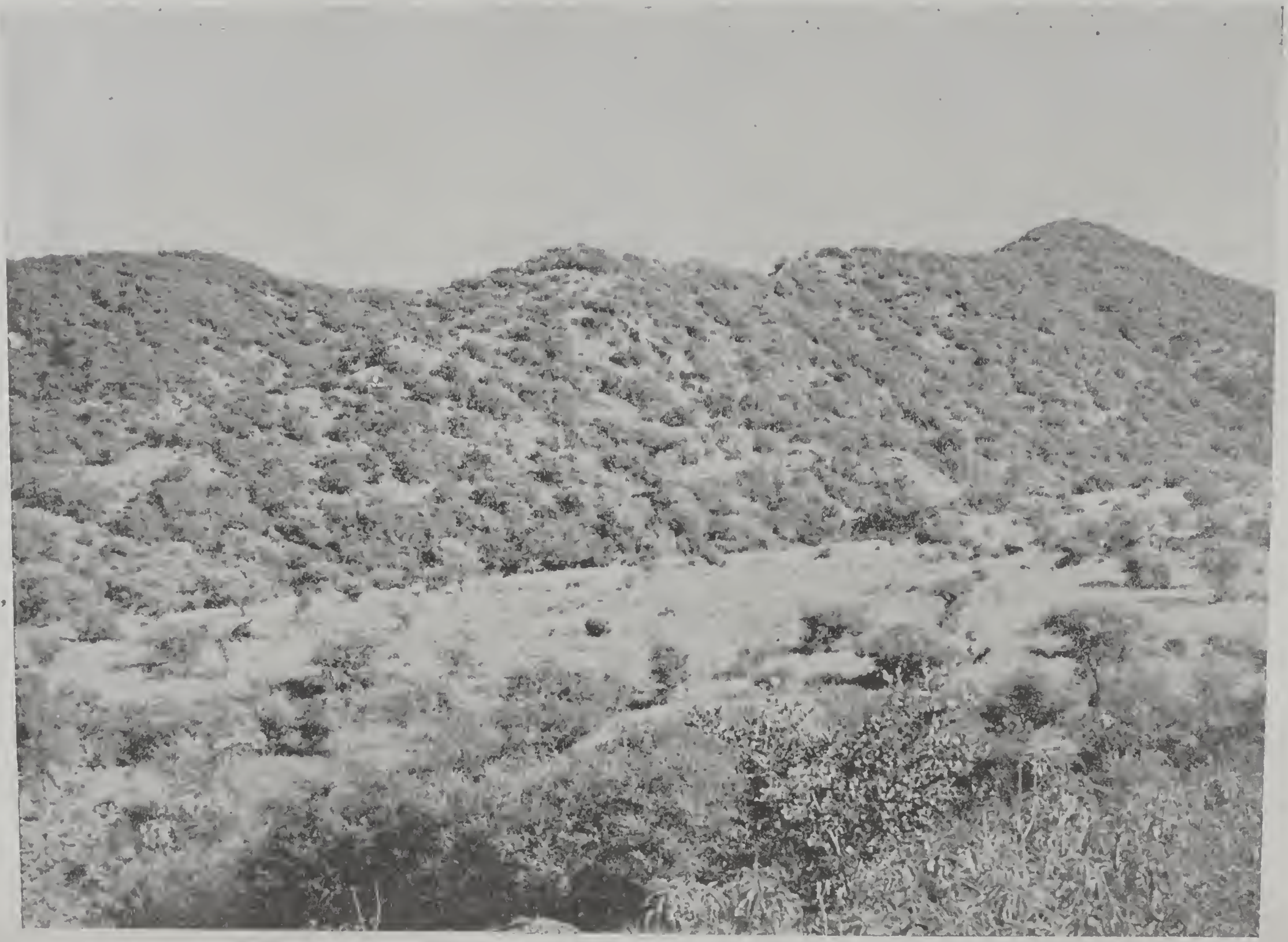
1a. Olea cuspidata scrub forest

Detailed descriptions are not available but in Hoshiarpur (Punjab), Himachal Pradesh and in Tons (U. P.) *Olea cuspidata* is distributed mainly on the flatter alluvial ground of the wider valleys where it has mostly been cleared for cultivation. COVENTRY (1929) considers the olive, which also extends a long way up the bigger valleys, e.g. the Beas, to represent the climax type, but it may not be able to establish itself on the drier sites. There is also a considerable overlap with the Siwalik *chir* pine. *Punica granatum* is locally abundant.

1b. Acacia modesta scrub forest

Acacia modesta characterises the mixed scrub of the hill sides, typically without *Olea*. *Acacia modesta* colonises denuded hill sides if adequate protection is afforded,

ILLUSTRATION.—Plate 74.



ACACIA MODESTA SCRUB FOREST

Acacia modesta rapidly colonising barren slopes after protection, Palaura, Jammu Division

DS1. Dodonaea scrub

Dodonaea viscosa may dominate over large areas and may be viewed as both a degradation stage and as a coloniser. MOHAN (1955) has listed the associated grasses, *viz. Cenchrus ciliaris, Chrysopogon fulvus, Eulaliopsis binata, Heteropogon contortus* and *Themeda anathera.*

FLORISTICS.—

Kala Chitta hills.—(KITCHINGMAN, etc.).

I. *Olea cuspidata**, *Acacia modesta**, *Pistacia integerrima* (o).

II. *Monotheca baxifolia, Gymnosporia royleana, Dodonaea viscosa**, *Carissa opaca, Adhatoda vasica.*

NOTE.—The forests are very much affected by grazing and lopping and considerable areas have been coppiced. Protection results in a pronounced closing up of the cover.

There is a fairly marked resemblance to the dry evergreen types of the Mediterranean area.

The status of *Punica* may be questioned but even if only a naturalized introduction it is often abundant and conspicuous in this type.

CHAPTER IX

MONTANE WET TEMPERATE FORESTS

GROUP 11. MONTANE WET TEMPERATE FORESTS

Sub-group 11A (Type C1). Southern Montane Wet Temperate Forests

1. NOMENCLATURE

Madras Kerala	Hill shola forests.

2. GENERAL DESCRIPTION

A closed evergreen forest, the trees being mostly short-boled and branchy though often attaining a considerable girth. The height of the forest is relatively low, rarely exceeding 6 m. The crowns are usually very dense and rounded with entire coriaceous leaves which tend to be red to a varying degree when young, giving a range of colours which is one of the most conspicuous features of the type. The branches are clothed with mosses, ferns and other epiphytes, and woody climbers are common. There is no marked differentiation of canopy layers, but a continuous series from under-shrubs and shrubs to the large trees. There is a considerable admixture of species, pure crops of even moderate extent being absent. The transition to the subtropical forest below is usually ill-defined.

The forest is usually found in patches (sholas) in the more sheltered sites on rolling grassland the origin of which is discussed below.

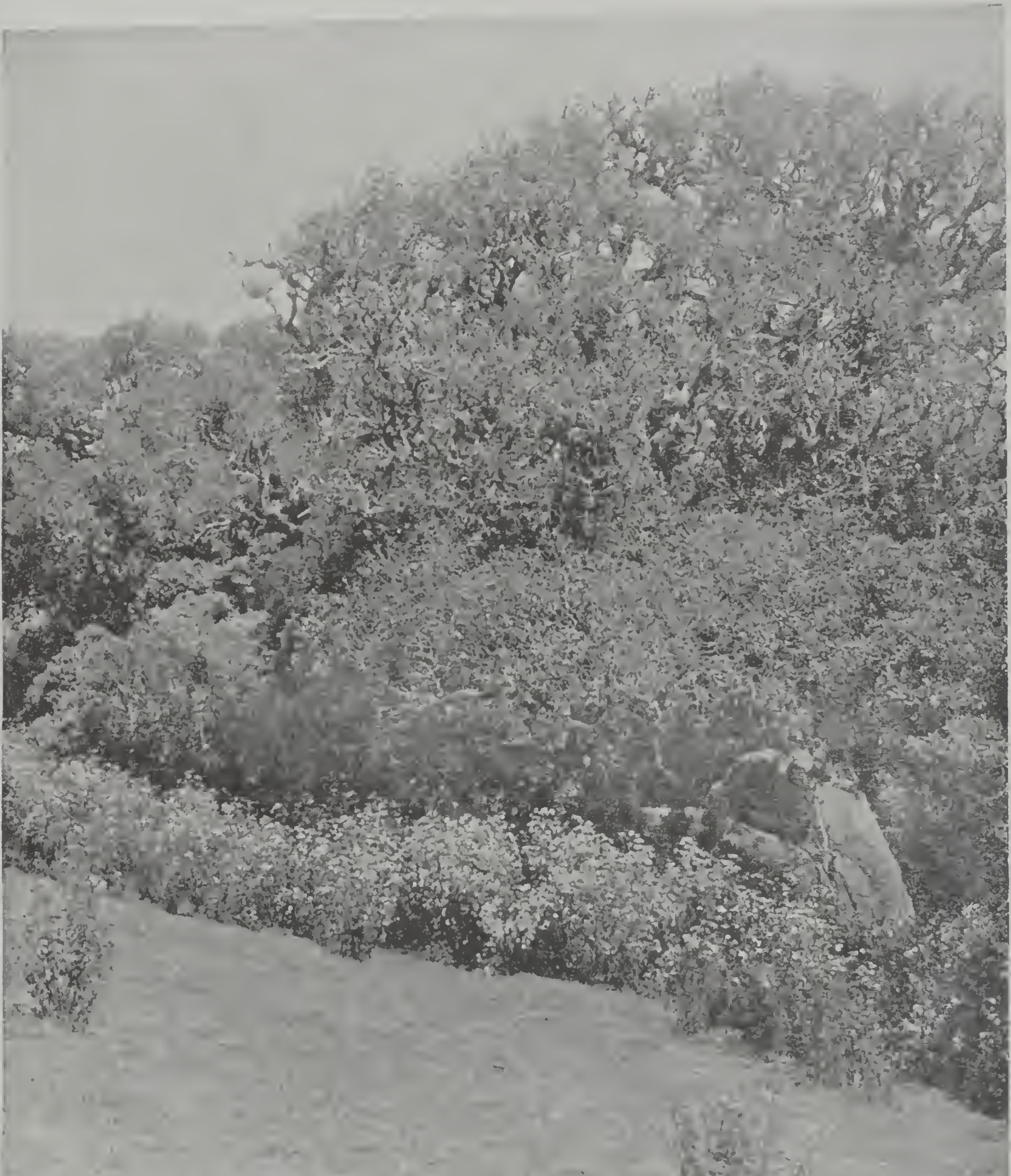
3. DISTRIBUTION

The higher hills of Madras and Kerala on the Nilgiri, Anamalai, Palni and Tirunelveli hills from about 1,500 m. upwards. (Very similar forest is met with in the higher parts of Ceylon, where it has been less altered by biotic influences.)

4. LOCALITY FACTORS

The climate in this type is perhaps the most equable experienced in India and is conditioned by the montane situation well within the tropics combined with a well distributed rainfall from both monsoons. Actually conditions vary considerably particularly with regard to the total rainfall and its detailed seasonal distribution. February is typically the driest month.

Temperature.—Data are given below for Ootacamund and Kodaikanal at about 2,300 m. in the higher part of the type and for Wellington at about 2,000 m. It may be noted that with the same mean temperature for the year at Ranikhet in the W. Himalayas (18·3°C) the annual range between the mean highest and lowest temperatures of the year is only 9°C for Wellington as compared with 13°C for Ranikhet; the difference is also well illustrated by the range of the monthly means which is 13°C to 19°C and 8°C to 22°C respectively.



SOUTHERN MONTANE WET TEMPERATE FOREST

Temperate evergreen *shola* with *Ilex wightiana*, *Myrsine wightiana*, *Eugenia* sp., *Mahonia* etc. and a fringe of *Eupatorium glandulosum* (between forest and grassland) which protects it from burning. Slokes Shola, Ootacamund, Madras.

H. G. Champion

Type 11A/C1

Temperature (centigrade)

Southern Montane Wet Temperate Forests

Month	Madras OOTACAMUND 2,245 m.			Madras COONOOR 1,749 m.			Madras KODAIKANAL 2,343 m.		
	Mean	Mean max.	Mean min.	Mean	Mean max.	Mean min.	Mean	Mean max.	Mean min.
January . .	12·5	18·8	6·6	13·7	19·0	8·3	12·4	16·8	8·1
February . .	13·2	19·7	6·6	15·3	21·0	9·5	13·2	17·8	8·6
March . .	15·0	21·1	8·8	17·0	22·7	11·3	14·6	19·0	10·1
April . .	15·7	21·9	9·5	18·7	23·7	13·7	15·9	20·2	11·7
May . . .	16·4	21·3	11·4	19·8	24·6	15·0	16·4	20·1	12·6
June . .	14·6	17·8	11·3	18·8	22·6	15·1	14·9	18·1	11·8
July . .	13·9	16·6	11·2	18·3	21·6	15·1	14·0	16·8	11·2
August . .	14·1	17·1	11·1	18·0	21·6	14·3	14·1	17·1	11·1
September . .	14·3	18·1	10·6	17·6	21·7	13·5	14·1	17·1	11·1
October . .	14·2	18·1	10·3	17·2	20·9	13·4	13·7	16·7	10·7
November . .	13·3	17·6	8·9	15·7	19·4	11·8	12·9	16·1	9·7
December . .	12·7	18·3	6·6	14·1	18·7	9·6	12·3	16·5	8·4
M. A. T. . .	14·2	..	..	17·0	..	..	14·0	..	..
Annual mean maximum .	18·9	..	..	21·4	..	..	17·7	..	..
Highest record .	26·1	..	..	29·4	..	..	27·8	..	..
Annual mean minimum . .	9·4	..	..	12·6	..	..	10·4	..	..
Lowest record .	1·7	..	..	2·2	..	..	2·8	..	..
No. of years .	40	..	..	10	..	..	50	..	..

Rainfall.—From 1,500 mm. upto 6,250 mm. or even more. The S.W. monsoon gives rain from April onwards with a maximum in June-July. This is followed by a drier August/September and then the N. E. monsoon sets in giving a second maximum in October. December to March is the driest period when there may be less than 50 mm. per month. The relative importance of the two monsoons depends on situation and exposure.

Rainfall (millimetres)

Southern Montane Wet Temperate Forests

Month	Madras OOTACAMUND 2,245 m.	Madras WELLINGTON 1,829 m.	Madras COONOOR 1,749 m.	Madras KODAIKANAL 2,343 m.
January	24	35	63	81
February	13	38	73	39
March	27	56	82	46
April	83	90	149	122
May	155	97	106	162
June	162	83	71	108
July	192	94	66	118
August	138	104	127	178
September	130	152	90	195
October	204	284	257	260
November	130	177	285	259
December	47	102	142	131
Total for year (M. A. R.)	1,303	1,312	1,512	1,689
Number of rainy days	99	88	85	107
Number of months with less than 50 mm.	4	2	0	2
M. A. Humidity	74	?	69	76
No. of years	55	30	10	40

Soil and Topography.—The underlying rock is crystalline throughout, mostly gneissic. This weathers to a reddish or yellow clayey soil topped by a varying depth of black soil rich in humus. In hollows and other wet sites, a regular peat is formed. When the forest cover is removed, this rich black soil is liable to be rapidly eroded with a marked drop in fertility.

The home of the type is on the rolling downs of the higher plateaux, a configuration rarely met with elsewhere in India (Khasi hills). As noted, the forests at present mostly occupy the sheltered folds in the hills.

Wind.—Exposure is an important factor in the development of these temperate evergreen forests and its effects are very obvious in the form of the trees and the appearance of the windward edge of the *sholas*.

Fire and Grazing.—In the dry season in February-March the grasslands get dry and inflammable and the greater part of them is burnt annually. This has happened as far back as we have any information and has unquestionably exerted a very great influence on the present distribution of the very fire tender evergreen forest. Burning completely stops regeneration of practically every tree species except *Rhododendron* and every fire eats in a little all along the periphery of the *sholas.* Nomadic graziers have occupied the plateaux for a very long time and have burnt the grass for the sake of the early flush of new growth that follows a fire, and it is unquestionable that the forest now occupies a far smaller proportion of the area than it once did.

5. FLORISTICS

The flora is a varied one including elements or both tropical and temperate origin; *Ternstroemiaceae* are well represented and *Eugenias* are important together with *Meliosma, Eurya, Symplocos* and *Lauraceae. Magnoliaceae* are represented by *Michelia* and with it are found such genera as *Ilex* and *Euonymus. Rhododendron nilagiricum* is as common and conspicuous as in the Himalayas and the *Ericaceae* are represented by *Gaultheria* and *Vaccinium.*

ILLUSTRATION.—Plate 75.

(i) *Sholas near Ootacamund, Nilgiri Hills, Madras.*—

I. *Ternstroemia gymnanthera**, *Eugenia calophyllifolia, E. arnottiana, E. montana, Michelia nilagirica, Gordonia obtusa, Xantolis tomentosa* (=*Sideroxylon tomentosum*), *Ilex wightiana, Meliosma wightii, Elaeocarpus* spp., *Photinia montana, Cinnamomum wightii, Litsea wightiana, Rhododendron nilagiricum**, *Euonymaus crenulatus, Glochidion neilgherrense, Symplocos laurina* etc.

II. *Turpinia cochinchinensis, Rhamnus wightii, Viburnum erubescens* etc., *Ligustrum* spp.

III. *Gaultheria fragrantissima, Psychotria congesta, Vaccinium leschenaultii, Mahonia leschenaultii* (*nepalensis*), *Strobilanthes* spp.

IVa. *Impatiens* spp.

V. *Rosa leschenaultiana, Clematis wightiana, Rubus* spp., *Schefflera* spp., *Elaeagnus latifolia, Toddalia asiatica.*

NOTE.—RANGANATHAN (1938) describes the considerable variation met with in the appearance and floristics of different parts of the plateau. Doubtless subdivision of the type will be made in due course with recognition of several associations.

6. NOTES

Whilst it is generally agreed that the *sholas* have been greatly reduced in extent even in recent times, there has been considerable controversy over the ecological status of the grassland. RANGANATHAN (1938) was of opinion that it is a climatic climax equally with the *shola* forest. Whilst tree growth may have been inhibited locally by frost, particularly in depressions where excessively swampy conditions may also prevail, we are of opinion that these adverse conditions have mainly been brought about by forest destruction, by clearing, fire and grazing, through the centuries. The grassland is accordingly here viewed as a stable degradation stage though possible edaphic or physiographic climax status might be accorded over restricted areas. Exposure to wind exerts an influential check on tree growth and renders large clearings slow to recover though burning is the primary inhibitory factor. Grasses occupy all clearings and periodic fires extend every grass patch eating away the forest till it is restricted to the damper sites. Introduced plants such as *Ulex* and *Sarothamnus* have occupied a lot of the ground lost to the forest apart from the planted *Eucalyptus* and *Acacias*, whilst the Nilgiri weed, *Eupatorium riparium*, appears to be checking the spread of fire into the *sholas* by forming a dense green belt along their edges. *Rhododendron nilagiricum* is practically the only tree which can persist in and colonise the burnt grasslands, and patches of *Gaultheria* are also characteristic. Locally *Rhodomyrtus*, *Hypericum mysorense*, *Dodonaca viscosa*, various *Melastomaceae* and *Rubus* spp. form shrub communities the origin and development of which also need study.

DEGRADATION STAGES OF SOUTHERN WET TEMPERATE FORESTS

DS1. Southern montane wet scrub

DESCRIPTION—Low evergreen scrub of varying density often with bracken fern and seedlings or stunted growth of *shola* species, notably *Rhododendron* and *Eugenia arnottiana*.

DISTRIBUTION.—Considerable areas on the downs occupying sites where *shola* forest probably existed earlier. A depauperated form also occurs on shallow rocky soils.

ILLUSTRATION.—Plate 76.

FLORISTICS.—

Rhodomyrtus (a), *Hypericum mysorense* (a), *Dodonaea viscosa* (la), *Mahonia leschenaultii*, *Berberis tinctoria*, *Rubus* spp., *Strobilanthes* spp., and *Pteridium aquilinum*.

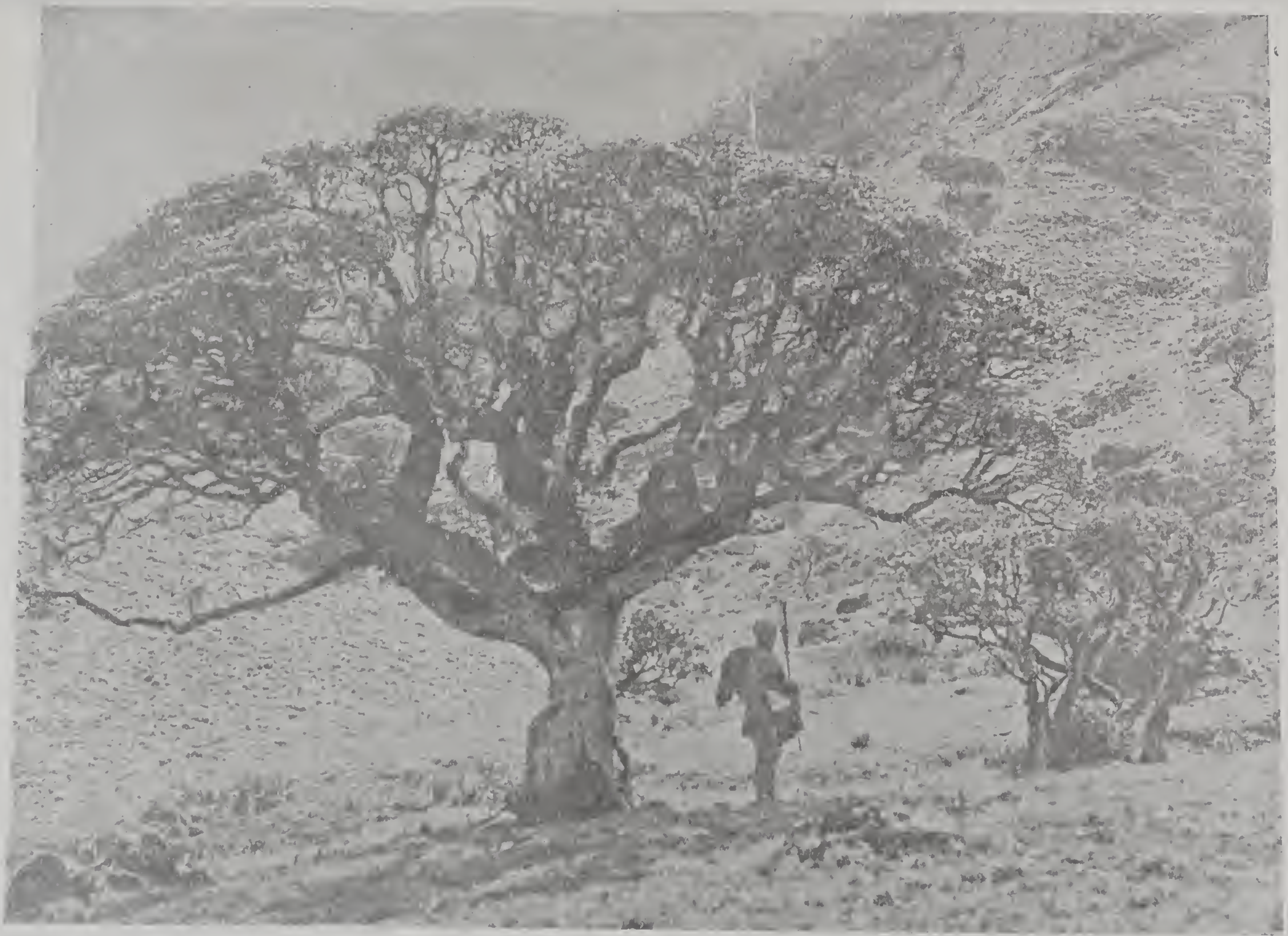
ECOLOGICAL STATUS.—There is every indication that most of this scrub would with protection gradually progress to the *shola* climax.

DS2. Southern montane wet grassland

DISTRIBUTION.—Over large areas on the rolling downland, *e.g.* Wenlock Downs.

LOCALITY FACTORS.—The highest parts and many depressions are subject to annual frost. Grazing is moderate to heavy. Fires are frequent though less common in parts as on the Wenlock Downs.

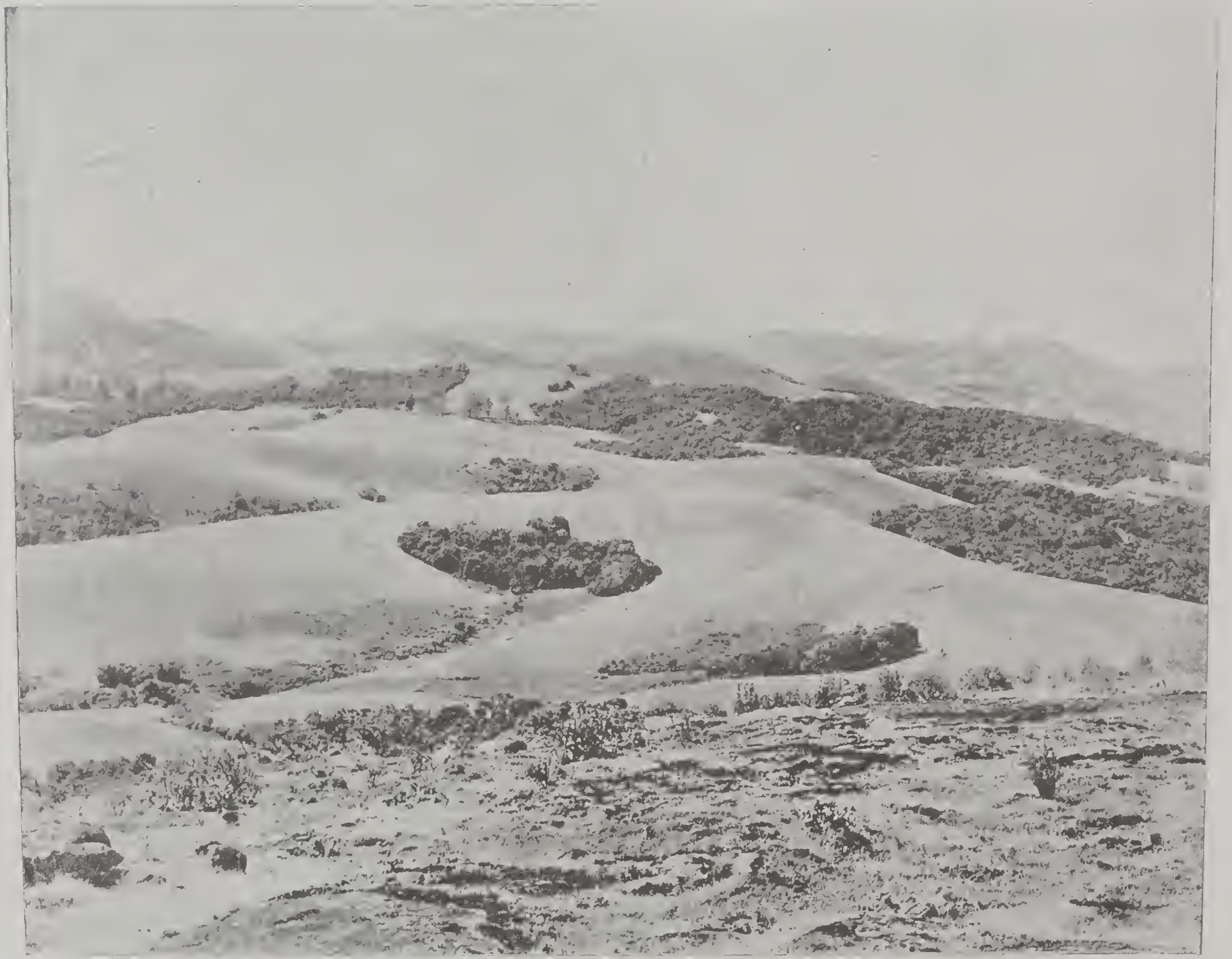
ILLUSTRATION.—Plate 77.



SOUTHERN MONTANE WET SCRUB

Mainly *Rhododendron nilagiricum* over denuded wasteland. Nilgiris, Madras.

A. F. Minchin



SOUTHERN MONTANE WET GRASSLAND

FLORISTICS.—(RANGANATHAN)

I. & II. Nil.

IVb. *Bothriochloa pertusa, Ischaemum pilosum, Themeda cymbaria, T. triandra, Cymbopogon polyneuros, Eragrostis nigra, Tripogon bromoides.*

ECOLOGICAL STATUS.—Though some writers have viewed this as climatic climax grassland, it is here considered as the ultimate degradation stage, stable under the current grazing and burning.

Sub-group 11B. Northern Montane Wet Temperate Forests

1. NOMENCLATURE

General	Tropical evergreen wet forest, upper zone (SCHWEINFURTH).
Bengal	Upper Hill forests (part). Middle Hill forests (part.). Upper Hill Zone (except top). (COWAN).
Assam	Hill forests (part).

2. GENERAL DESCRIPTION

Closed evergreen high forest of trees of large girth but medium height, rarely over 25 m. and usually with large branching crowns festooned with mosses, ferns, aroids and other epiphytes. Deciduous species occur particularly at the higher altitudes but form a relatively small proportion of the crop. Although the forest is essentially a mixed one there is a marked tendency for a few species to predominate strongly, notably the oaks and *Lauraceae*. There is typically an evergreen underwood at least wherever the top canopy is not too dense. At the high elevations, a dwarf bamboo undergrowth is very generally developed and may be very dense and uniform over large areas. Climbers occur and include some large woody forms but are not generally conspicuous.

At the higher elevations, consociations of silver fir may be met with but are best considered with the next type, developed under a rather less wet climate.

3. DISTRIBUTION

This type occurs in the E. Himalaya from E. Nepal eastwards on the higher hills of Bengal, Assam and N. E. F. A. from 1,800 m. to 3,000 m. where it merges with the sub-alpine forest.

4. LOCALITY FACTORS

Full data are only available for a few stations but Darjeeling is fairly representative for the type lying near the middle of the altitudinal range. Kurseong illustrates the conditions prevailing on the outer range with high rainfall, but is rather below the usual altitudinal limit of the type.

Temperature.—It will be noted that the mean minimum for the middle of the zone is near to freezing point during the three winter months December to February.

Temperature (centigrade)

Northern Montane Wet Temperate Forests

Month	Bengal DARJEELING 2,265 m.			Bengal KURSEONG 1,494 m.			Assam SHILLONG 1,500 m.			Naga Hills KOHIMA 1,463 m.		
	Mean	Mean max.	Mean min.	Mean	Mean max.	Mean min.	Mean	Mean max.	Mean min.	Mean	Mean max.	Mean min.
January	5·1	8·3	1·9	10·1	13·3	7·2	9·7	15·6	3·8	11·5	14·9	8·1
February	5·7	8·8	2·6	12·2	14·4	7·8	11·4	16·9	5·8	13·5	17·1	9·9
March	9·6	13·0	6·1	15·6	19·4	11·7	15·9	21·3	10·4	18·1	22·2	14·0
April	12·8	16·2	9·3	17·8	21·7	14·4	18·7	23·4	13·9	19·3	23·1	15·4
May	14·3	17·2	11·3	19·4	22·8	16·1	19·2	23·3	15·1	20·9	23·8	18·1
June	15·9	18·3	13·6	20·0	22·8	17·8	20·4	23·6	17·2	21·4	24·1	18·7
July	16·6	18·7	14·4	20·6	23·3	18·3	21·1	24·1	18·1	21·1	23·5	18·6
August	16·5	18·7	14·3	20·6	22·8	18·3	20·9	23·9	17·8	20·9	23·5	18·3
September	15·7	18·1	13·3	20·6	23·3	17·8	20·0	23·5	16·4	21·3	24·0	18·5
October	13·3	16·5	10·1	18·3	21·7	15·6	17·2	21·7	12·7	19·7	22·5	16·9
November	10·2	13·1	6·2	15·0	18·9	11·7	12·5	18·9	6·1	16·4	19·4	13·3
December	6·4	10·3	2·6	12·2	16·1	8·9	10·4	16·4	4·4	11·5	14·7	8·3
M. A. T.	11·8	..	..	16·7	..	..	16·5	..	..	18·0	..	..
Annual mean maximum	14·7	..	..	20·0	..	..	21·1	..	..	21·1	..	..
Highest record	27·1	..	..	?	..	..	32·2	..	..	?	..	..
Annual mean minimum	8·8	..	..	13·8	..	..	11·9	..	..	14·9	..	..
Lowest record	—5·0	..	..	?	..	..	—2·8	..	..	?	..	..
No. of years	60	..	..	?	..	..	?	..	..	60	..	..

Rainfall.—The type occurs with a high monsoon rainfall of at least 2,000 mm. and often a great deal more. The winter months November to March are relatively dry with less than 60 mm. monthly but good showers fall in April. The monsoon reaches its climax in July when rain falls almost daily and the monthly fall is 750 mm. or more, August being nearly equally wet. Dense mist is a characteristic of these forests during the monsoon months making them among the darkest and gloomiest in India.

Rainfall (millimetres)

Northern Montane Wet Temperate Forests

Month	Bengal DARJEELING 2,265 m.	Bengal KURSEONG 1,494 m.	Assam SHILLONG 1,500 m.	Naga Hills KOHIMA 1,463 m.
January	14	17	13	13
February	29	28	27	32
March	44	41	50	56
April	104	100	130	97
May	215	295	287	178
June	588	807	461	321
July	797	1,072	347	407
August	638	874	317	403
September	446	625	300	251
October	130	126	171	107
November	22	14	41	31
December	7	9	7	8
Total for year (M.A.R.)	3,034	4,044	2,150	1,904
Number of rainy days	123	132	122	122
Number of months with less than 50 mm.	5	5	4	4
M. A. Humidity	83	..	75	..
No. of years	59	58	35	62

Soil and Topography.—In Sikkim most of the type occurs on gneissic rock with sandy loam soils usually rich in dark humus in the upper layers.

The ground is entirely hilly and usually steep.

Biotic factors.—In the E. Himalayas, the forests of this zone have suffered to a very varying extent from clearing for uncontrolled shifting cultivation and the forest has been pushed back along the periphery of permanent settlement. It has been considerably affected by grazing and graziers at the higher altitudes, and fires through the bamoo brakes have destroyed a great deal of the forest replacing it by pure bamboo. The extension of potato cultivation has also led to much destruction of forest. Forestry operations involving clearfelling and replanting have covered most of this type near Darjeeling.

5. GENERAL FLORISTICS

The prevalence of oaks and chestnuts characterise these forests particularly at the higher altitudes, whilst the laurels are equally abundant and actually predominate over the oaks at the lower levels. *Magnoliaceae* are represented throughout the type but though conspicuous when in flower, do not ordinarily contribute greatly to the canopy, *Engelhardtia* and *Schima* extend fairly freely up from the lower forests and *Khododendron* down from the sub-alpine forests above. *Acer*, *Prunus*, *Ulmus* and other deciduous genera of Palaearctic distribution are also a feature. The *Ericaceae* are represented by *Vaccininum* and other genera, and *Araliaceae* frequently occur; *Symingtonia* (=*Bucklandia*) may also be mentioned.

6. SUB-DIVISIONS

The Darjeeling/Sikkim occurrence is well known and can be divided into three altitudinal zones as described below.

Along the Assam/Burma border the oak forests extend to lower altitudes than in the Himalayas and as in the south of India there seems to be no marked differentiation between the sub-tropical and temperate vegetation, oaks and *Magnoliaceae* being characteristic from the tropical associations at about 1,000 m. to the *Rhododendron* forests at about 2,750 m. If the Himalayan floristic element were omitted, it would be difficult to differentiate a subtropical zone at all, and we should only have the tropical forests of the lower levels predominating upto say 1,000 m. with the temperate above and a vertical overlap of 300 m. or more ; *Dipterocarps* would be taken as characterising the former and oaks the latter.

The following types are described :

C1. East Himalayan wet temperate forests.

- *Ia. Lauraceous forest.*
- *Ib. Buk oak forest.*
- *Ic. High-level oak forest.*

C2. Naga Hills wet temperate forest.

C1. East Himalayan wet temperate forests

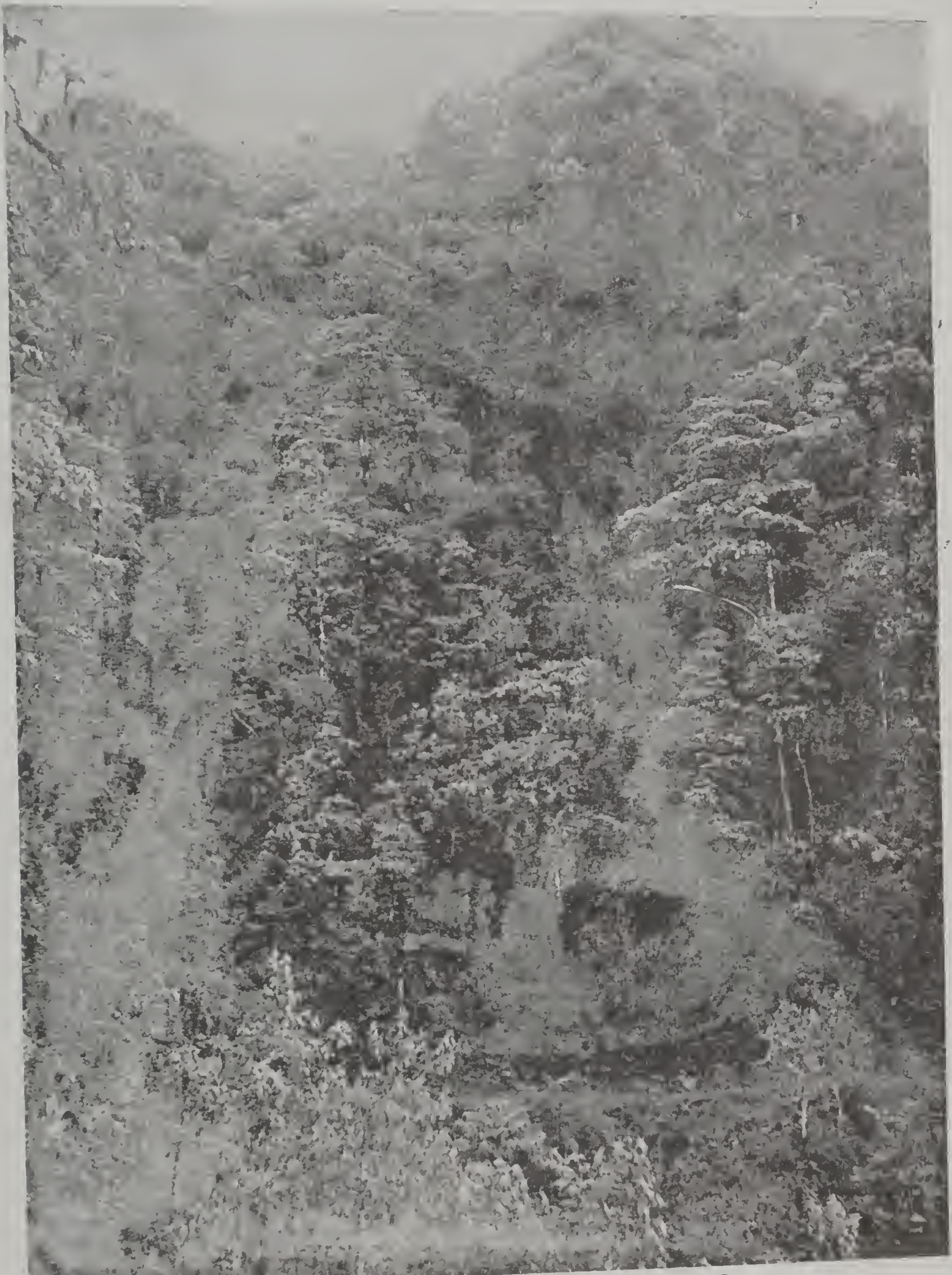
NOMENCLATURE.—

Quercus-Michelia-Acer-hylium of Aka Hills (BOR).

Quercus-Magnolia-Acer-hylium of Manipur (DEB).

DESCRIPTION.—As for the sub-group 11B given above.

DISTRIBUTION.—Outer Himalayan ranges in (W. Nepal), Bengal, Sikkim (Bhutan) and Assam between 1,750 m. and 2,750 m. and at the upper levels of the Manipur and Naga Hills.



NORTHERN MONTANE OAK FOREST

Quercus lamellosa, Q. lineata, Acer campbellii, Michelia excelsa and *Castanopsis tribuloides* over *Magnolia, Symplocos, Rhododendron, Machilus, Litsea* underwood with evergreen undergrowth including *Arundinaria maling*. Above Rambi, Darjeeling Division, West Bengal.

M. V. Laurie

LOCALITY FACTORS.—As given for the subgroup above, Darjeeling being representative. Three altitudinal zones may be distinguished characterized by the predominance of *Lauraceae*, *Quercus lamellosa* and *Q. pachyphylla* respectively, occupying very roughly the zones 1,800—2,100 m., 2,100—2,400 m., and 2,400—2,750 m. though freely overlapping with variation in topography and exposure.

ILLUSTRATION.—Plate 78.

FLORISTICS.—(Percentages refer to total number of trees over 3′ girth at breast height).

C1a. Lauraceous forest

(i) *Kalimpong Divison, West Bengal.* 1,800—2,100 m. (*Machilus-Michelia hylium* of COWAN).—

I. *Machilus edulis** (12%), *Alcimandra (Michelia) cathcartii* (8%), *Beilschmiedia* spp. (5%), *Cinnamomum obtusifolium* (2%), *Litsea* spp. (1½%), *Machilus* sp. (1½%), *Magnolia campbellii* (2%), *Engelhardtia spicata* (7%), *Schima wallichii* (5%), *Castanopsis tribuloides* (3%), *Lithocarpus spicatus* (2%), *Prunus nepalensis* (3%), *Mallotus nepalensis* (2½%), *Betula alnoides* (2½%), *Acer laevigatum* (1%), *A. campbellii* (1%).

II. *Eurya acuminata*, *Symplocos theaefolia*, *Araliaceae*, *Ilex* spp., *Turpinia cochinchinensis*, *Mahonia* spp.

(ii) *Kalimpong Division, West Bengal.* 2,100 to 2,400 m. (COWAN).—

I. *Alcimandra cathcartii* (17%), *Magnolia campbellii* (2%), *Machilus edulis* (7½%), *Litsea* (7½%), *Beilschmiedia* (2½%), *Machilus* (2½%), *Cinnamomum* (1%), *Quercus fenestrata* (7%), *Castanopsis* (7%), *Araliaceae* (4%), *Symplocos* (4%), *Prunus nepalensis* (3½%), etc.

C1b. BUK Oak forest

(i) *Kalimpong Division, West Bengal.* 2,150 to 2,440 m. (*Quercus hylium* of COWAN).—

I. *Quercus lamellosa** (12½%), *Castanopsis tribuloides* (3%), *Acer campbellii* (5½%), *Michelia doltsopa* (4%), *Alcimandra cathcartii* (1%), *Sloanea dasycarpa* (1%).

II. *Machilus* spp. (21½%), *Litsea* spp. (16%).

IIa. *Arundinaria* spp.

III. *Rubus* spp., *Strobilanthes* spp.

NOTE.—The oaks contribute the greater part of the large trees of the top canopy, the *Lauraceae* being relegated to the second storey though numerically predominant.

BOR describes very similar forest as a *Quercus-Michelia-Acer-hylium* in the Aka Hills with rainfall over 5,000 mm. He records consociations of *Q. lamellosa, Q. pachyphylla, Acer campbellii* and *Michelia* (*doltsopa*) as occurring within the type.

DEB also records very similar forest in Manipur at 1,800—2,400 m. with a rainfall of about 3,500 mm., whilst with a lower rainfall of 1,750 mm. a *Quercus-Rhododendron hylium* is found with lower height and poorer flora in which the oaks are associated mainly with *Rhododendron arboreum* and *Lyonia* (*Pieris*). Both types have been much disturbed by human agency.

(ii) *Singalila Range, Preservation Plots* 9 *and* 10, *Darjeeling Division, W. Bengal.* 2,150 to 2,440 m.—

I. *Quercus lamellosa*, Q. lineata, Michelia doltsopa*, Acer campbellii**.

II. *Symplocos theaefolia, Machilus gammieana, Betula alnoides, Carpinus viminea.*

IIa. *Arundinaria maling.*

III. *Daphne cannabina, Viburnum* spp.

IVa. *Polygonum* sp. and many ferns.

NOTE.—These plots are behind the main range where the rainfall may be about 2,000 mm.

C1c. High level oak forest

Darjeeling Division, W. Bengal. 2,440 to 2,750 m. (CHAUDHURY).—

I. *Quercus pachyphylla*, Q. lamellosa, Castanopsis tribuloides, Acer campbellii, Magnolia campbellii.*

II. *Symplocos theaefolia, Taxus baccata.*

IIa. *Arundinaria* spp.

III. *Rubus, Strobilanthes.*

GENERAL NOTES.—*Alnus nepalensis* occurs mainly along water courses and is also the chief colonist on new landslips.

Viburnum erubescens is very typical of waste lands in this zone.

C2. Naga Hills wet temperate forest

DESCRIPTION.—Apparently generally similar to the Himalayan forest, with some features such as frequency of low rounded crowns and short boles in common with the southern wet temperate forests.

DISTRIBUTION.—Higher hills along the Assam/Burma border from 1,800 m upwards.

LOCALITY FACTORS.—Hilly country on gneissic ranges, usually less steep than the Himalayas and including more rounded and rolling plateau land on which the forest is broken up by grasslands somewhat similar to those of the Nilgiris in South India. The rainfall is less than that of the foregoing type.

FLORISTICS.—(TROUP).

I. *Magnolia**, *Manglietia*, *Michelia**, *Quercus**, *Acer*, *Prunus*, *Pyrus*, *Symingtonia* (*Bucklandia*) *populnea*, *Alnus nepalensis*, *Betula alnoides*, *Carpinus viminea* etc.

IIa. Bamboo in the east.

III. Evergreen shrubs.

NOTE.—TROUP gives this as the drier type of hill forest, parallel to but less luxuriant than the wetter type already described as a subtropical formation.

CLARKE on floristic grounds describes the vegetation at the higher levels in the Naga Hills as more like that of Sikkim than that of Khasi Hills.

GROUP 12. HIMALAYAN MOIST TEMPERATE FORESTS

1. NOMENCLATURE

General	Temperate oak and conifer forest, temperate conifer forest of W. Himalaya and tropical evergreen montane forest, upperbelt. (SCHWEINFURTH).
Jammu & Kashmir and Punjab	Temperate broadleaved and coniferous forests (WORKING PLANS).
Himachal Pradesh	Moist zone forests (excluding *chil* pine) of Sutlej Valley (GORRIE). Temperate zone forests (excluding *chil* pine).
Uttar Pradesh.	Broadleaved sclerophyll forests (DUDGEON and KENOYER). *Quercus-Abies* and *Quercus-Acer* associations (OSMASTON).
Bengal and Assam	*Tsuga Abies* association (COWAN). Hemlock and fir forests of Upper Hill Forests (WORKING PLANS).

2. GENERAL DESCRIPTION

The chief character of this type is the extensive development of coniferous forests though conifers also pre-dominate in the sub-tropical pine forests, in dry temperate forests, and locally in the sub-alpine forests. These coniferous forests are very similar to those of other parts of the North temperate zone in Europe and America. The number of dominant species is small, in fact more or less pure crops are almost more frequent than mixed ones, the species found being dependent mainly on altitude and aspect. There is relatively little admixture with broadleaved trees in the west, but the evergreen oaks, etc., become increasingly important and conspicuous as one goes eastwards. The conifers generally form a somewhat open forest of good height 30 to 50 m. (or more) with a very varying amount of underwood which is mostly evergreen usually with the oaks strongly predominating. The conifers tend to avoid hot southern exposures being there replaced by oak forests. RAIZADA (1960) has recently collected records of the distribution of the Himalayan coniferous species.

The oak forests are usually composed mainly of single species depending on the altitude, and are usually of low height (10-20 m.) with widely branching crowns and poor boles but may be much better developed on good soils and in sheltered sites free from lopping et .

A deciduous shrubby undergrowth is almost always present, its luxuriance being largely determined by the density of the canopy and the intensity of grazing. Some evergreen shrubs such as *Sarcococca*, *Daphne*, and *Skimmia* are also met with, and *Strobilanthes* spp. may occur gregariously over considerable areas. Climbers of temperate genera such as *Rosa*, *Clematis*, *Hedera* are frequent but unimportant. Mosses and ferns grow freely on the branches but woody epiphytes are few compared with the wet temperate forests of the E. Himalayas. Dwarf bamboos (*Arundinaria* spp.) form extensive brakes in some localities but are often absent. The whole area under this type of forest is subjected to heavy grazing (chiefly sheep and goats) and lopping and so is broken up by grassy openings, known as *marg* (Kashmir), *thach* (Punjab) or *bughial* (Garhwal). On pool sites the forest is often reduced to a broken scrub. A rather luxuriant herbaceous vegetation is developed during the summer but is flattened in the winter by rain and snow.

3. DISTRIBUTION

This formation extends along the whole length of the Himalayas between the subtropical pine forests and the sub-alpine formation with a rainfall between about 1,000 and about 2,500 mm. The course of the isophyets results in the displacement of the formation from the outer ranges at the eastern end of the range by the wet temperate forests (without conifers), and in the change to the dry temperate forests in the inner ranges. These types are thus met with in Kashmir, Himachal Pradesh, Punjab, Uttar Pradesh, (Nepal), Darjeeling district of Bengal, Sikkim (and Bhutan). The altitudinal range is from about 1,500 m. up to 3,300 m. the limits varying with aspect and configuration.

4. LOCALITY FACTORS

Full data are available for some of the hill stations which are however mostly in the outer ranges and in the oak rather than in the coniferous forests.

Temperature.—Data for seven stations are given, but none of these is in the heart of the moist coniferous forests. Darjeeling is in the wet temperate forests but serves to illustrate the conditions prevailing in the E. Himalayas.

Temperature Data (centigrade)

Himalayan Moist Temperate Forests

Month	J. & K. SRINAGAR 1,537 m.			J. & K. GULMARG 2,655 m.			Punjab SIMLA 2,202 m.			Punjab DALHOUSIE 2,042 m.		
	Mean	Mean max.	Mean min.	Mean	Mean max.	Mean min.	Mean	Mean max.	Mean min.	Mean	Mean max.	Mean min.
January . .	1·2	5·0	—2·6	..	..	..	5·3	8·6	1·9	5·3	8·8	1·8
February .	2·7	6·7	—1·4	..	..	..	5·8	9·3	2·3	9·2	13·6	4·8
March . .	8·3	13·8	2·8	..	..	..	10·2	13·9	6·4	13·4	17·6	9·2
April . .	12·9	18·8	7·0	..	..	..	14·6	18·8	10·3	14·9	20·2	9·6
May . .	17·6	25·0	10·2	..	..	..	18·6	22·9	14·3	17·9	22·4	13·5
June . .	21·9	29·7	11·8	14·2	19·9	7·3	19·8	23·9	15·6	23·8	28·7	18·8
July . .	24·5	31·0	17·9	15·9	21·5	10·9	18·4	21·6	15·1	19·9	23·2	16·7
August . .	23·9	30·3	17·4	14·2	20·5	10·9	17·7	20·2	15·1	18·7	21·3	16·2
September .	20·3	28·6	11·9	9·7	17·5	6·2	16·9	20·2	13·5	18·8	22·3	15·3
October . .	14·0	23·2	4·8	..	..	..	14·4	17·9	10·8	14·9	19·1	10·8
November .	8·5	16·9	0·1	..	..	..	10·7	14·6	6·8	13·5	18·4	8·6
December .	3·3	9·0	—2·4	..	..	..	7·2	10·3	4·1	8·6	12·5	4·5
M. A. T. .	13·3	..	..	?	..	..	13·3	..	..	14·9	..	..
Annual mean maximum .	19·9	..	..	?	..	..	16·9	..	..	19	..	..
Highest record	37·2	..	..	?	..	..	30·6	..	..	?	..	..
Annual mean minimum .	6·6	..	..	?	..	..	9·7	..	..	10·8	..	..
Lowest record .	—2·2	..	..	?	..	..	7·2	..	..	?	..	..
No. of years .	50	..	..	40	..	..	60	..	..	?	..	..

Temperature Data—(contd.)

Month	U. P. CHAKRATA 2,134 m.			U. P. RANIKHET 1,850 m.			U. P. MUKTESWAR 2,314 m.		
	Mean	Mean max.	Mean min.	Mean	Mean max.	Mean min.	Mean	Mean max.	Mean min.
January . .	5·6	10·6	1·7	7·8	12·8	5·6	5·9	9·9	1·9
February . .	6·1	10·6	1·7	8·9	12·8	4·4	6·2	10·3	2·1
March . .	10·6	16·7	6·7	13·9	18·3	9·4	10·6	15·2	5·9
April . .	15·6	21·1	10·0	18·3	22·8	13·3	15·1	19·9	10·2
May . .	17·8	22·8	12·8	20·0	24·4	15·9	18·1	22·8	13·2
June . .	19·4	23·9	15·6	21·7	25·6	17·8	18·7	22·9	14·4
July . .	17·8	21·1	15·6	20·0	23·3	17·2	17·6	20·8	14·4
August . .	17·8	21·1	15·0	19·4	22·8	16·7	17·1	20·0	14·1
September . .	17·2	20·6	14·4	18·9	22·8	16·1	16·3	19·8	12·8
October . .	14·4	18·9	19·6	16·1	20·6	12·2	14·1	18·3	9·8
November .	10·6	15·0	6·1	12·8	13·7	8·3	10·5	14·9	6·1
December . .	7·8	13·8	3·9	9·4	13·9	6·1	7·7	11·8	3·6
M. A. T. . .	15·3	..	..	15·6	..	..	13·2	..	..
Annual mean maximum .	17·9	..	..	19·7	..	..	17·2	..	..
Highest record .	29·4	..	..	30·0	..	..	30·6	..	..
Annual mean minimum .	9·5	..	..	11·1	..	..	9·1	..	..
Lowest record .	4·4	..	..	—1·1	..	..	—7·8	..	..
No. of years .	?	..	..	?	..	..	40	..	..

Rainfall and Humidity.—Throughout the area, the precipitation is mainly derived from the S. W. monsoon and falls during July to September. In the N. W. an appreciable proportion however is brought by N. W. disturbances during the winter months fading out towards the east; this falls largely as snow and is undoubtedly a factor of importance in determining the type of forest met with. Thus it is clear that the occurrence of deodar forests is determined by a not too heavy monsoon fall and a good winter snowfall. In the east the heavy monsoon rainfall appears to be the chief reason for the absence of conifers other than *Abies* from the outer hills. Data are given for 12 stations.

Rainfall (millimetres)

Himalayan Moist Temperate Forests

Month	J. & K. SRINAGAR 1,587 m.	J. & K. GULMARG 2,655 m.	J. & K. UDHAMPUR 655 m.	Punjab NAGAR 1,829 m.	Punjab DALHOUSIE 2,042 m.	Punjab SIMLA 2,202 m.	H.P. KOTGARH 1,951 m.	U.P. CHAKRATA 2,134 m.	U.P. NAINITAL 1,981 m.	U.P. KAUSANI 1,798 m.	U.P. RANIKHET 1,850 m.	U.P. MUKTESWAR 2,314 m.
January	74	..	100	128	181	61	61	58	70	61	58	55
February	72	..	107	135	169	68	74	69	75	75	59	64
March	92	..	88	145	98	61	82	81	63	64	47	48
April	93	..	49	94	76	54	68	33	29	39	32	36
May	60	..	36	62	54	67	72	46	76	82	3	58
June	36	90	96	69	130	174	107	201	367	232	148	186
July	59	103	380	191	557	425	242	551	727	446	334	314
August	61	118	394	194	563	434	235	584	692	371	33	311
September	39	67	136	103	174	160	113	203	332	200	167	201
October	30	..	23	31	34	34	22	25	59	48	38	48
November	11	..	10	23	19	12	13	10	11	12	8	11
December	34	..	48	55	98	28	30	28	25	29	24	27
Total for year (M.A.R.)	660	478	1,467	1,229	2,152	1,573	1,118	1,885	2,516	1,657	1,313	1,360
Number of rainy days	57	?	66	80	96	86	69	?	92	89	77	82
No. of months with less than 50 mm.	4	?	5	2	2	3	3	5	3	3	5	5
M. A. Humidity	70	?	?	?	?	56	?	?	?	?	?	63
No. of years	50	40	41	58	20	75	75	?	77	34	65	40

Soils and Topography.—The forests cover most of the rock formations of the Himalayas, and so occur chiefly on gneisses and schists extending over quartzites, granites, limestones, conglomerates and shales. The soil likewise shows a wide range but loams probably predominate. Typical temperate soil profiles are built up and acid humus may accumulate to considerable depths, particularly in the spruce forests (cf. TAYLOR, 1935).

Other factors.—Fires are liable to sweep up into these forests from the inflammable pine forests below them and be very destructive, particularly to the other conifers which are fire tender. The large oaks will stand a leaf fire without appreciable harm but regeneration is killed. Particularly illuminating examples are to be seen in Darjeeling district where fires in the bamboo broken have swept far up the slopes.

Grazing and its concomitant, lopping, on the other hand have exerted a very great influence on the oaks. Many of the lower forests especially in the *Quercus incana* belt have been reduced to scrub or low pollard, or even completely eliminated. In the higher oak and conifers, large blanks have come into existence round the frequented grazing camps, usually on the gentler slopes and often richest soils by the annihilation of tree regeneration and the gradual destruction of the over-wood by peeling bark, lopping for fuel and fodder, burning and so on ; these blanks are almost everywhere spreading. The rapid destruction by lopping of the broadleaved strips along ravines and depressions has been recorded in many districts. Mountain bamboo (*ringal*) brakes have also replaced tree forest under similar circumstances (cf. p. 316).

Snow slides often occur and wipe out strips of forest along their course. They become more prevalent with the destruction of the higher forests, the conifers being eliminated whilst a cover of hardwoods and shrubs maintains a precarious hold.

Wind is surprisingly unimportant in the Himalayas and the only marked effects on the forests are the occasional strips flattened by avalanche winds, and the windswept edges of the oak forests along ridge crests.

5. GENERAL FLORISTICS

The prevalence of conifers has been mentioned. The chief genera are *Abies*, *Cedrus*, *Picea*, *Tsuga* and *Pinus* (*P. wallichiana*); *Cupressus* and *Taxus* also occur. Among the broadleaved trees, the genus *Quercus* with several species is by far the chief, and its commonest associate is *Rhododendron*, notably *R. arboreum*, throughout the range with other species coming in at the higher altitudes and towards the east, the centre of distribution of the genus. The temperate deciduous tree genera, *Acer*, *Corylus*, *Aesculus*, *Prunus*, *Ulmus*, *Carpinus* and *Betula*, are met with fairly generally and form local consociations. *Lauraceae* are very generally present, notably *Litsea*, *Lindera* and *Machilus*, but in contrast with the wetter eastern forests play only a subordinate role. *Euonymus* and *Ilex* are other common evergreen tree genera. *Arundinaria* and related genera of dwarf bamboos are very typical of these forests being represented by a number of species. Among the shrubs, *Indigofera*, *Desmodium*, *Rubus* and *Viburnum* are typical, whilst

Strobilanthes spp. may be locally conspicuous; the virtual absence of oaks from the Kashmir valley and the Upper Ganges valley (GUPTA, 1960) is noteworthy particularly as all five species of the W. Himalayas were present in early pleistocene times as also the conifer *Larix*. The herbaceous flora includes *Impatiens, Plectranthus, Senecio, Dipsacus* and *Heracleum* as conspicuous elements.

6. SUBDIVISIONS, SUCCESSION, ETC.

In the W. and C. Himalayas, the three common oaks provide a simple and convenient basis for subdivision into three altitudinal zones each with its typical coniferous counterpart. Aspect, exposure, soil and history as usual greatly disturbed the natural altitudinal distribution. The factors determining the presence or predominance of coniferous forest in relation to the oak have not been worked out, but the oaks appear to be good indicators of the growth conditions for the conifers on a given site. The oak-fir forest of the E. Himalayas is so similar to that of the W. Himalayas that the two may be co-ordinated and the hemlock forests which extend eastwards from Kumaon to Assam are accepted as equivalent of the mixed coniferous forest of the west. Mixed deciduous forest is generally found in depressions and ravines. At lower elevations, *Alnus* borders the water-courses extending down into the sub-tropical zone.

C1. *Lower Western Himalayan temperate forests.*
1a. *Ban oak forest (Q. incana).*
1b. *Moru oak forest (Q. dilatata).*
DS1. *Oak scrub.*
1c. *Moist deodar forest (Cedrus).*
1d. *Western mixed coniferous forest (spruce, blue pine, silver fir).*
1e. *Moist temperate deciduous forest.*
1f. *Low-level blue pine forest (P. wallichiana).*
DS1. *Oak scrub.*
DS2. *Himalayan temperate secondary scrub.*
C2. *Upper West Himalayan temperate forests.*
2a. *Kharsu oak forest (Q. semecarpifolia).*
2b. *West Himalayan upper oak/fir forest.*
2c. *(Moist temperate deciduous forest.)*
C3. *East Himalayan moist temperate forest.*
3a. *East Himalayan mixed coniferous forest.*
3b. *Abies delavayi forest.*

Degradation stages of Himalayan moist temperate forests

DS1. *Montane bamboo brakes.*

*DS*2. *Himalayan temperate parkland.*

*DS*3. *Himalayan temperate pastures.*

General edaphic and seral types of Himalayan moist temperate forests

*E*1. *Cypress forest.*

1*S*1. *Alder forest.*

1*S*2. *Riverain blue pine forest.*

2*S*1. *Low-level blue pine forest.*

In describing these types, it is more convenient to deal separately with the predominantly broadleaved and predominantly coniferous forests whatever view is taken of their ecological relationship. The following diagram compares Eastern and Western forms :

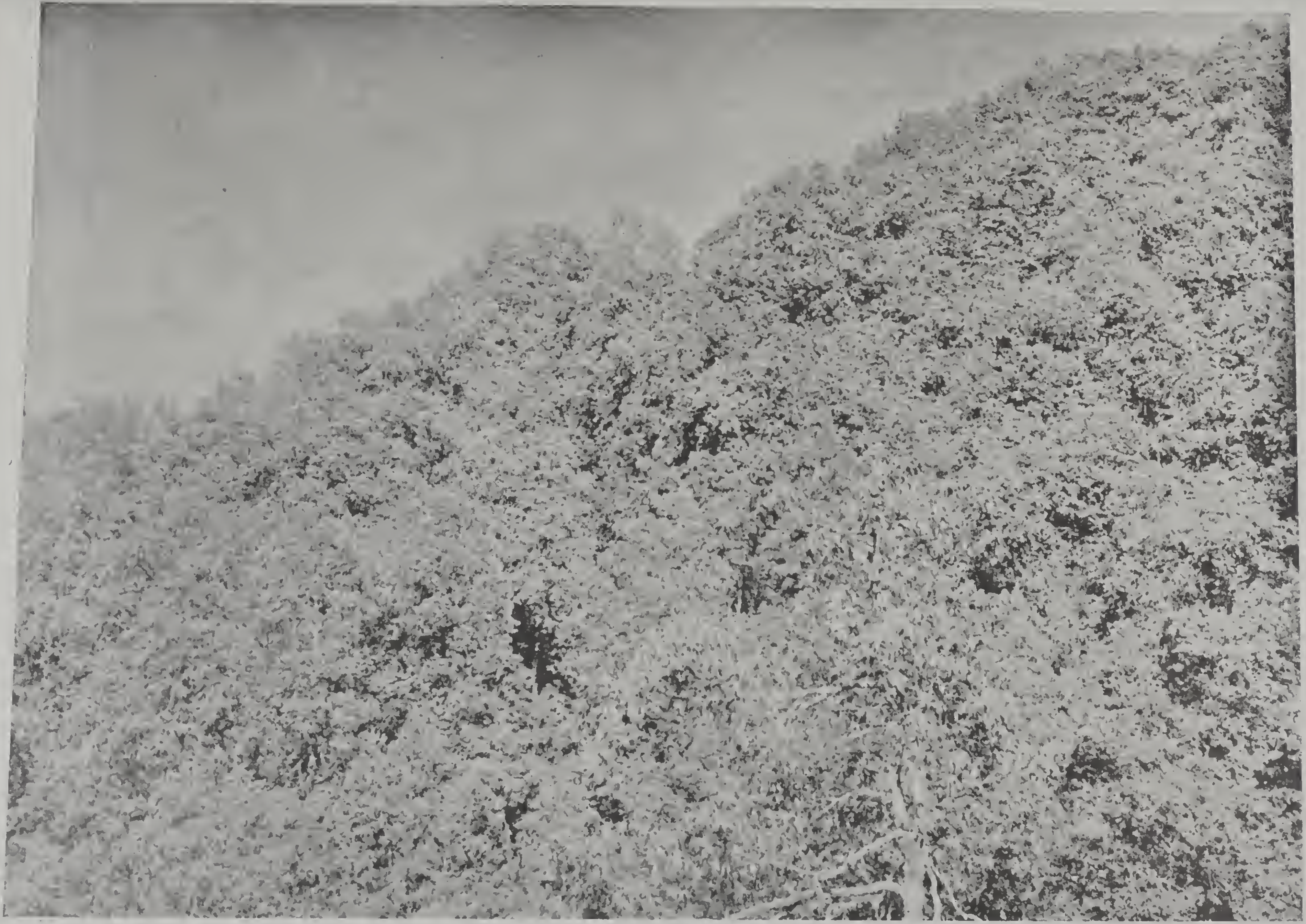
Altitude	Western Himalaya		Eastern Himalaya	
	Broadleaved	Coniferous	Coniferous	Broadleaved
3,000 m.	Sub-alpine *Birch-Rhododendron*	*Abies spectabilis*	(*Abies densa*)	(*Rhododendron-Betula*)
2,500 m.	C2a. *Q. semecarpifolia*	*Abies pindrow*	C2c. *Abies densa* *Tsuga dumosa* *Picea spinulosa*	*Q. pachyphylla* *Q. lamellosa*
2,250 m.	*Q. dilatata*	C1e. *Abies pindrow* *Picea smithiana*	*Tsuga dumosa*	*Q. lamellosa* *Q. lineata*
2,000 m.	*Q. incana*	C1d. *Moist deodar* C1f. (*Lower Kail*)	..	..
1,500 m.	(Subtropical)	(*Pinus roxburghii*)	(*Pinus roxburghii*)	(*Shorea robusta*)

The successions in the different altitudinal zones are markedly similar, especially in the very widespread occurrence in the west and central parts of *Pinus wallichiana* as the pioneer tree species in both primary and secondary seres but there are naturally differences in floristics and other details. A diagram is given at the end of 12/C1 on page 310.

C1. Lower Western Himayalan temperate forests

C1a. Ban oak forest (Quercus incana)

DESCRIPTION.—When well developed, the trees form a closed canopy about 20 m. high (up to 25 m.). More usually they form a somewhat open forest of rather short-boled and low branchy trees though often of considerable girth, and on southern aspects the cover may be decidedly incomplete. In damp ravines and other favourable sites, there may be an appreciable mixture of deciduous trees contributing to the main canopy, whilst at the other extreme, on dry hot slopes, these are entirely absent ; *Rhododendron*



BAN OAK FOREST

Pure *Quercus incana* forest at 600 m. Dalhousie Municipal Forests, Punjab. *G. S. Mathauda*

arboreum and *Lyonia ovalifolia* (both inedible to cattle and bad fuels) are very typical associates, usually below the oak canopy. There may be a well defined largely evergreen second storey on damp sites, and where it is not too heavily grazed there is generally a good deal of shrubby undergrowth of both deciduous and evergreen species. Climbers are few, *Rosa moschata* and *Hedera* being the commonest, but there is much moss and lichen on the trees and in the monsoon a copious development of epiphytic ferns, *Arum*, *Sedum*, etc. and even orchids.

There is very little grass in the better quality forests but a thick grass cover is developed on all but very shallow soils when the cover is broken. *Pteridium aquilinum* is usually present in such places and the slopes are often full of flowers in the monsoon. Though a little *Arundinaria falcata* occurs in shady places, bamboos are generally absent.

Many of the forests have been coppiced in the past and so present a decidedly different appearance from the original undisturbed form.

DISTRIBUTION.—Occupies the lowest portion of the temperate belt, particularly in the outer ranges and on southern aspects. It occurs most extensively in the Central Himalayas, Uttar Pradesh and Himachal Pradesh. *Q. incana* extends a long way downwards practically right through the subtropical zone on the moister sites. Absent from Kashmir but extends into NEFA.

LOCALITY FACTORS.—The climatic data given for Ranikhet, Chakrata, Kausani and Dharmsala are quite representative. The altitudinal zone occupied is roughly between 1,800 m. and 2,300 m. on southern aspects but lower by 150 to 300 m. on northern slopes and in ravines—occasionally a good deal lower. There is a wide overlap with the *chir* pine forest which may extend up the ridges even to 2,300 m. In comparison with the other moist temperate types, it occupies drier as well as warmer sites, and may be viewed as their least mesophytic form. A monsoon rainfall seems necessary and a high snowfall unfavourable, these conditions perhaps contribute to the replacement of the type in Kashmir by coniferous forest.

Geological formation has very little influence on the distribution of the oak forest which builds up a good soil rich in humus. The ground is naturally mostly well-drained and the oak occupies all but really wet soils where deciduous trees take its place.

The *ban* oak forests are very exposed to damage or destruction through human agencies, being at a favourable altitude for settlement and cultivation, and these agencies increase the already somewhat xerophytic conditions. Lopping is extremely prevalent and combined with fuel and charcoal demands has led to the final disappearance of the forest over large areas : the damage falls more heavily on the oak than the other species. Shifting cultivation has led to the clearing of considerable areas of *ban* oak forest, particularly on the gentler slopes and better soils, potatoes being the chief crop. Hill tea has also displaced much oak forest in some localities.

The *ban* oak forests are not themselves inflammable but in many localities suffer a good deal from fires spreading up from the pine zone below, in fact these fires have been an important factor in determining the present distribution of the oak excluding it from much territory it can reinvade given protection (cf. CHAMPION, 1919, 1923).

ILLUSTRATION.—Plate 79.

FLORISTICS.—Although *Quercus incana* is by far the commonest oak, *Q. lanuginosa* forms local consociations of varying extent and *Q. glauca* is locally abundant especially along shady ravines, usually at the lower elevations. Typical grasses have been listed by MOHAN (1955), and SETH (1954).

(i) *Binsar, W. Almora division, U.P.* 1,650 m. Good forest.—

I. *Quercus incana** (va), *Carpinus viminea* (r), *Cedrela serrata* (lo).

II. *Rhododendron arboreum* (a), *Lyonia ovalifolia* (a), *Euonymus pendulus* (f), *Ilex dipyrena* (o), *Betula alnoides* (o), *Lindera pulcherrima* (lf), *Litsca umbrosa* (o).

III. *Viburnum cotinifolium* (f), *Desmodium tiliaefolium* (f), *Indigofera gerardiana* (f), *Rubus niveus* (f), *Boenninghausenia* (f), *Myrsine africana* (lf), *Deutzia staminea* (f).

IV. *Vitis* spp. (o), *Hedera* (f), *Smilax parvifolia* (f).

(ii) *Girichina, W. Almora division, U.P.* 1,500 m. Village forest type.—

I. & II. *Quercus incana** (60 per cent), *Rhododendron arboreum* (a), *Lyonia ovalifolia* (a), *Rhus semialata* (f), *Symplocos crataegoides* (o), *Pyrus pashia* (o), *Benthamidia* (=*Cornus*) *capitata* (r), *Castonopsis tribuloides* (r).

III. *Berberis lycium* (f), *Indigofera gerardiana* (f), *Viburnum cotinifolium* (f), *V. coriaceum* (f), *Lonicera quinquelocularis* (f), *Reinwardtia* (f), *Strobilanthes dalhousianus* (f), *Leptodermis* (f), *Desmodium tiliaefolium* (o), *Rubus ellipticus* (o).

IVa. *Pteridium aquilinum* (a), *Plectranthus strictus* (a), *Myriactis* sp. (f), *Agrimonia* (f).

IVb. Thin grass.

V. *Vitis himalayana* (a), *Rosa moschata* (o).

Par. *Loranthus* sp. (a).

NOTE.—On red clay loam over limestone on a N aspect. Forest much grazed.

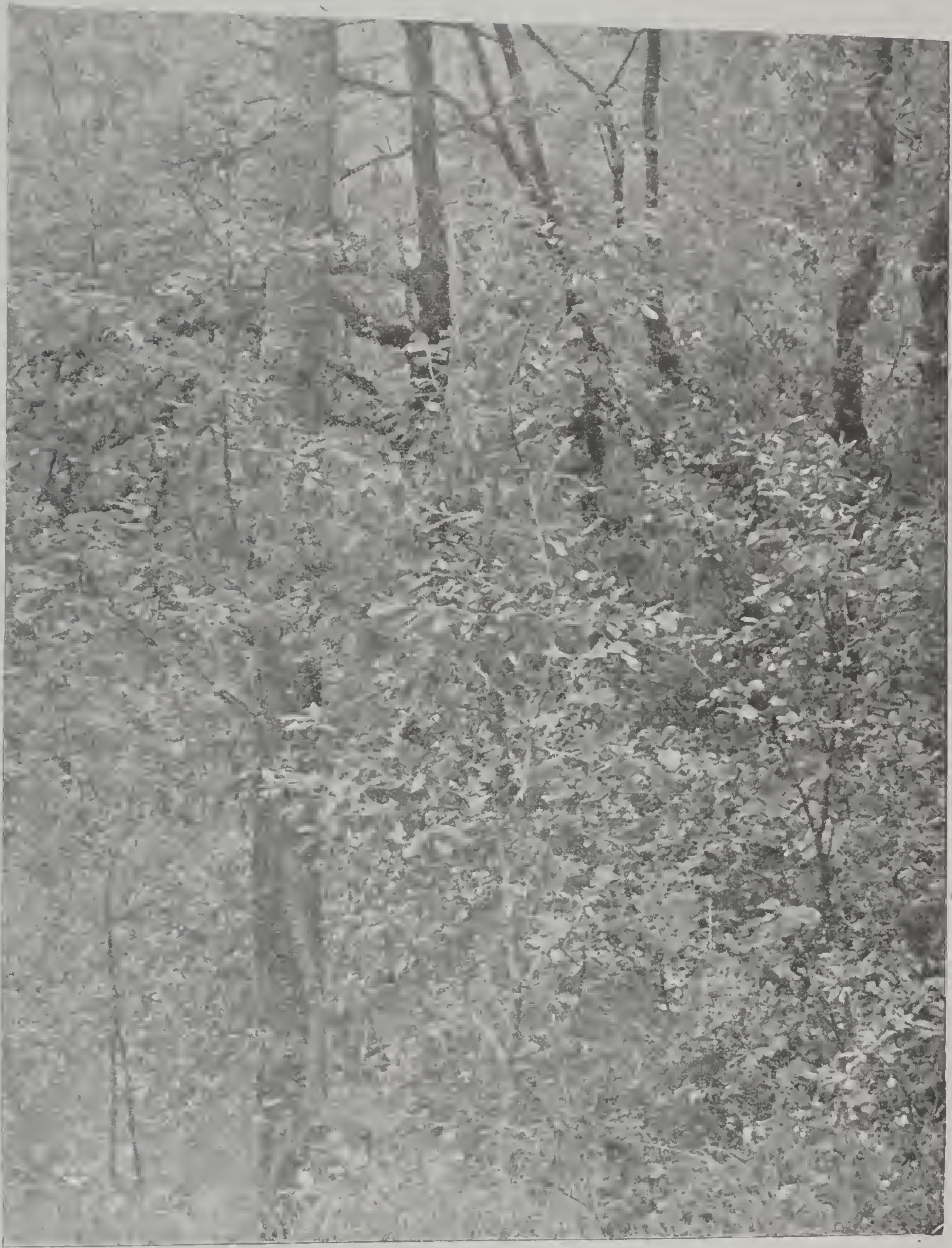
(iii) *Garhwal, Uttar Pradesh* (OSMASTON)—

The description given indicates close similarity to (i) above. Consociations of *Carpinus faginea* are reported to occur.

(iv) *Chichiot Forest, Nichar, Himachal Pradesh*—

I. & II. *Q. incana**, *Rhododendron arboreum*, *Lyonia*, *Machilus odoratissima*, *Litsea umbrosa*, *Myrica sapida*, *Symplocos crataegoides*, *Benthamidia capitata*.

NOTE.—Good forest of Q.C. I with occasional *Pinus wallichiana*, *P. roxburghii* and *Cedrus* on drier ridges.



MORU OAK FOREST

Natural regeneration of *Quercus dilatata* in protected catchment areas. Simla, Punjab.

G. S. Mathauda

ECOLOGICAL STATUS.—It seems agreed that this type is definitely a climatic climax, the present distribution having been considerably reduced by human influences particularly clearing, grazing and lopping. Reference has been made above under the *chir* pine forest (p. 271) that many ecologists incline to the view that *ban* oak is the climax over the greater part of the area now dominated by the pine, and the same conclusion is reached for the lower parts of the *kail* and *deodar* forests.

We feel that this view goes too far in altogether denying climax status to the conifers and that more probably whilst they have undoubtedly greatly extended their dominance into the broadleaved types, they are still entitled to climax status over a significant proportion of the sites they now occupy.

All stages of degradation occur to thin oak scrub (cf. OSMASTON, Pl. XV), the composition of the underwood being completely changed by overgrazing and fire. Intensive lopping and grazing may reduce the *ban* forest to an open grass-tree type with practically pure *Rhododendron* (near Dharmsala, etc.).

The occurrence of consociations of *Quercus lanuginosa* is limited to quartzite outcrops in Nainital district according to SMYTHIES, but not so in Almora (CHAMPION). TROUP records a consociation of *Q. glauca* at 1,500 m. on a northern aspect in Mandi (Himachal Pradesh).

Quercus, *Rhododendron arboreum* and *Lyonia* are all absent from Kashmir.

C1b. Moru oak forest (Quercus dilatata)

DESCRIPTION.—With the damper climate and sites affected, and a warm summer despite a pronounced cold winter, this type is definitely more luxuriant than the *ban* oak, and forms in fact some of the finest moist temperate broadleaved forests. The height is typically 20 to over 30 m. but can attain 44 m. (TROUP) the trees having relatively long clean boles. There is a greater admixture of secondary species in the top storey, mainly of deciduous trees and a well marked evergreen second storey of *Rhododendron*, *Lauraceae*, *Euonymus*, *Ilex*, etc. and there is a shrubby undergrowth of *Rubus*, *Spiraea*, and *Viburnum* with some evergreen such as *Skimmia* and *Sarcococca*, but in the inner hills of Kumaon this may be largely displaced by a dense growth of *Arundinaria*. The growth of epiphytic ferns and herbs is less pronounced than in the *ban* forests and that of mosses less than in the high level oak, but epiphytes are none the less conspicuous during the monsoon months, especially ferns and bryophytes.

Both the *ban* and *kharsu* oaks extend freely into the *Quercus dilatata* zone, frequently meeting on the ridges which are avoided by the last mentioned. At the same time fairly extensive almost pure crops of *Q. dilatata* occur. Of the conifers *Picea* is perhaps the commonest associate. The typical grasses have been listed by MOHAN (1955) and SETH (1954).

DISTRIBUTION.—A relatively narrow belt above the *ban* oak, about 2,000 to 2,5000 m. in the C. Himalaya largely replaced by conifers in the western parts of the range.

LOCALITY FACTORS.—This is a definitely more mesophytic type than the *ban* oak which displaces it on dry ridges and hot southern aspect. It is thus adapted to temperatures averaging 4° C or 5° C cooler and a moister atmosphere, and fairly high soil moisture also appears to be needed. Climatic data are only available for the lower altitudinal limit in the outer ranges : the figures for Simla and Chakrata, both at about 2,000 m. may be seen. Snow falls every year and may lie for several weeks.

Quercus dilatata appears to be the most appreciated of the oaks for leaf fodder, so that the more accessible forests are very heavily lopped, but their greater distance from the centres of population sometimes protects them to a considerable extent. On the other hand, the villagers themselves sometimes protect a strip of oak adjoining the village expressly for lopping. *Q. dilatata* is less fire-hardy than *Q. incana* but the forests are too damp to burn except when fires sweep up from below in exceptional years.

ILLUSTRATION.—Plate 80.

FLORISTICS.—

(i) *Bhatkot E., C. Almora Division, Uttar Pradesh* (OSMASTON).—

I. *Quercus dilatata** (a), *Q. incana* (o), *Abies pindrow* (lf).

II. *Euonymus pendulus* (a), *Ilex dipyrena* (o), *Rhamnus purpureus* (o), *Lindera pulcherrima* (lf), *Eurya acuminata* (f), *Rhododendron arboreum* (f), *Meliosma dilleniaefolia*, *Cedrela serrata* (lo), *Pyrus lanata* (f), *Lyonia ovalifolia* (f), *Machilus duthiei* (f), *Fraxinus micrantha* (r), *Betula alnoides* (o), *Taxus baccata* (o).

IIa. *Arundinaria* spp. (f), *A. jaunsarensis* (lf).

III. *Rosa macrophylla*, *Rubus niveus*, *R. biflorus*, *Myrsine semiserrata*, *Viburnum* spp., *Berberis aristata*, *Strobilanthes wallichii*, *S. alatus*, *Deutzia corymbosa*.

V. *Hedera nepalensis* (f), *Clematis montana*.

(ii) *Preservation Plot No. 22 (1932), Chakrata Division, U.P.* 1,700 m.—

I. *Quercus dilatata** (a), *Q. incana* (o), *Aesculus* (o), *Celtis australis* (f), *Abies spectabilis* (r), *Picea* (r), *Cedrus* (r).

II. *Ilex dipyrena* (f), *Machilus odoratissima* (f), *Betula alnoides* (o), *Acer caesium* (f).

IIa. *Arundinaria jaunsarensis*.

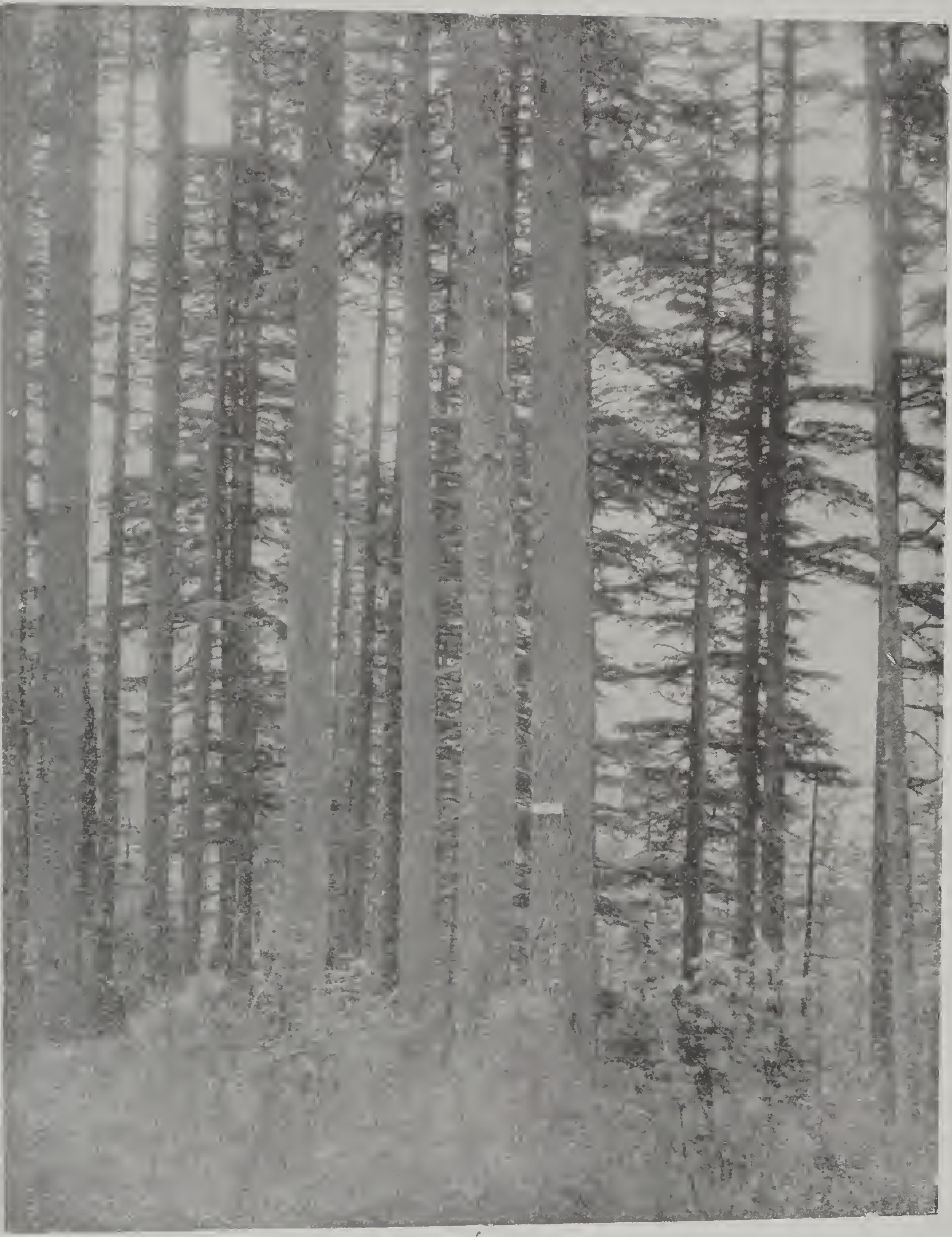
III. *Indigofera gerardiana*, *Daphne cannabina*, *Sarcococca*, *Desmodium*.

IV. Ferns numerous.

(iii) *Garhwal Himalayas, Uttar Pradesh*.—

I. *Quercus dilatata**, *Q. incana*, *Q. semecarpifolia*, *Betula alnoides*, *Carpinus viminea*, *Acer caesium*, *Machilus duthiei*.

II. *Euonymus pendulus*, *Ilex dipyrena*, *Rhamnus purpureus*, *Eurya acuminata*, *Buxus sempervirens* (quite small societies), *Lindera pulcherrima*, *Litsea umbrosa*, *Lyonia ovalifolia*, *Staphylea emodi*, *Symplocos ramosissima*, etc.



MOIST DEODAR FOREST

Evenaged group of *Cedrus deodara* with natural regeneration of *Pinus wallichiana* on clearing in foreground
Kadrala, Lower Bashahr Division, Himachal Pradesh.

H. G. Champion

IIa. *Arundinaria* spp.
III. *Boenninghausenia, Salix elegans, Skimmia laureola, Strobilanthes wallichii, Viburnum cotinifolium.*
IV. *Geranium wallichianum,* etc.
V. *Hedera nepalensis.*

NOTE.—"*Quercus dilatata* requires very favourable conditions for it to form consociations of its own......The canopy is generally dense and there is nearly always a thick second storey". (OSMASTON).

(iv) *Sutlej Valley, Himachal Pradesh* (GORRIE)—

The *Quercus dilatata* occurs mainly as an underwood in the blue pine belt but locally forms consociations very similar to those met with in Kumaon and Garhwal.

ECOLOGICAL STATUS.—The *Quercus incana/Q. dilatata* and *Q. semecarpifolia*, tension lines in Kumaon in relation to human activities have been discussed by CHAMPION [1923 (1)]. Degradation to tree scrub or shrub cover results in oak scrub and temperate mixed scrub described below and on p. 309.

12/C1(a'b)/DS1. Oak scrub

DESCRIPTION.—The oaks and associated species are reduced to low stunted unsound trees, usually coppice whilst *Rhododendron arboreum* tends to be left as useless for villagers' purposes. With it are bushes of *Berberis* spp., *Crataegus, Prinsepia,* etc. (all thorny) and sometimes *Spiraea, Indigofera, Wikstroemia,* etc. Short grass covers the soil (with some *Pteridium aquilinum,* on the deeper pockets) where it is not completely exposed by the trampling.

DISTRIBUTION.—Area adjoining or easily accessible to settlements extending from *ban* up into the *Q. dilatata* type.

LOCALITY FACTORS.—Intense lopping for fodder and litter combined with a continuous grazing and more or less fuel and pole felling. The soil is usually badly eroded and often completely stripped.

ILLUSTRATION.—OSMASTON (1922), Pl. XV.

NOTE.—If the same areas are completely cleared of tree growth the secondary temperate scrub described on p. 309 may come into existence.

C1c. Moist deodar forest (Cedrus)

DESCRIPTION.—The forest is perhaps typically nearly pure deodar but more or less blue pine and a little spruce are commonly present. Most of the forests seen appear to have been considerably influenced directly or indirectly by human activities and so are not in truly climax condition. The canopy is typically fairly complete but not very dense (except locally in young crops) and the boles are straight and tall ; a height of 30-40 m. is usual. There are usually scattered oaks and *Rhododendron* under the conifers and a scrub growth depending in amount largely on the intensity of grazing. Towards the west, the tall shrub pohu (*Parrotia jacquemontiana*) may form a dense underwood comparable with *Corylus avellana* in Europe.

An analysis of full vegetation lists of 50 deodar sample plots showed that whilst *Viburnum cotinifolium* and *Indigofera gerardiana* are common practically throughout, the presence of *Quercus dilatata, Q. incana, Lonicera angustifolia, Rosa moschata, Jasminum officinale* and *Daphne papyracea* differentiate the moist type here under consideration from the dry temperate type dealt with later. GORRIE (1933) has discussed the ecological significance of the occurrence of many of the common plants of the deodar forests, both moist and dry.

DISTRIBUTION.—From Garhwal north-westwards through Tehri, Jaunsar, Himachal Pradesh, the Punjab (notably the Beas Valley at Kulu), Jammu and Kashmir with the exception of the northern slopes of the Pir Panjal Range, mainly between the outer wet ranges and the inner dry zone. Isolated occurrences further east, *e.g.*, in Kumaon, Uttar Pradesh, appear to have spread from planted trees, especially near temples.

The deodar forests cover practically the same altitudinal range as the *ban* and *moru* oaks, *viz.*, 1,700-2,500 m. similarly extending appreciably lower on cool aspects and much higher even to 3,000 m. or more (GUPTA, 1960) on sunny ridges ; they avoid, however, the outer ranges and regions of high rainfall (particularly high monsoon rainfall) and extend into a much drier climate.

LOCALITY FACTORS.—The *rainfall* is typically 1,100—1,800 mm. and the monthly falls given for Simla or Nagar on p. 293 illustrate the normal seasonal distribution. Appreciable winter snowfall seems to be necessary and this is probably a significant factor in its absence eastwards.

The significance of *humidity* in addition to the rainfall and its distribution has been brought out by SHER SINGH (1929) as a possible explanation for the absence of deodar on the Pir Panjal in Kashmir; high humidity is unfavourable to this type but favourable to fir.

Temperature data are not available for any typical station in the deodar forests nor even any station of comparable altitude in the north-west where winter rainfall is important. The figures for Srinagar, which lies at 1,500 m. and receives only 660 mm. rainfall, are given on p. 293 and provide an interesting comparison with those of Simla (2,200 m.) in the same table.

The type occurs on all geological formations but avoids badly drained soil. (This is adduced as another possible reason for the absence of deodar forests on the heavier soils of the gentle north slopes of the Pir Panjal). In the moist parts of Garhwal it is mainly found on steep rocky limestone slopes indicating preference for the driest situations (OSMASTON 1922). Some deodar soils have been investigated by TAYLOR, MEHTA and HOON (1934).

Fire does not usually originate in the deodar forests but is very liable to sweep up from the *chir* or blue pine forests below and occasionally causes wholesale destruction particularly in young crops (*e.g.*, at Nagni, Kulu, in 1921). It has undoubtedly always been a factor of importance and influential in determining the relative distribution of deodar, blue pine and *chir* in the existing forests.

Grazing is usually heavy throughout the deodar forests except where especially excluded. If not excessive, it does not greatly affect forest type and may even be helpful in its maintenance, by reducing the herbaceous ground cover and so facilitating tree regeneration.

ILLUSTRATION.—Plate 81.

FLORISTICS.—

(i) *Lower Bashahr Sample Plots.*—

I. *Cedrus deodara**, *Pinus wallichiana* (r).

II. *Quercus incana* (r).

III. *Rosa macrophylla* (f), *Berberis lycium* (f), *Lonicera angustifolia* (f), *Strobilanthes wallichii* (f), *Boenninghausenia*, (lf), *Deutzia staminea* (f).

IV. *Adiantum lunulatum* (a), *Lastraea* spp. (f).

V. *Hedera nepalensis* (f), *Jasminum officinale* (o), *Clematis montana* (o), *Vitis himalayana* (r).

NOTE.—These plots are in the best stocked areas and grazing is prevalent in all of them.

(ii) *Kulu Division, Punjab.*—

NOTE.—OSMASTON's (1931) analysis of the vegetation associated with good natural regeneration in two plots in this Division showed that the presence of grass, *Galium asperifolium*, *Salvia glutinosa*, *Fragaria indica*, *F. vesca*, *Viola canescens*, moss, *Indigofera heterantha*, *Desmodium tiliaefolium* and *Oxalis corniculata* are characteristic, and the depth of humus only varied between 12 and 25 mm.

MOHAN (1955) and SETH (1954) have listed the typical grasses.

ECOLOGICAL STATUS.—The relation between deodar and blue pine is discussed on p. 320. Blue pine is met with almost throughout the moist deodar area, sometimes in mixture, sometimes as more or less pure crops. The latter are considered here as seral communities and stages in their progression to deodar are commonly seen ; [SURI (1933) cites Paneo in Seraj division as a good example].

At the same time, deodar may itself be ousted by spruce in the spruce zone (Takrasi, etc., in Seraj).

DUDGEON and KENOYER (1924) consider the deodar forests in Tehri Garhwal to be an edaphic climax in a broadleaved sclerophyll formation on dry sites, much the same as for the *chir* pine. PARKER (1924), MOHAN and PURI (1957) have expressed similar views for the Punjab, Himachal Pradesh and Kashmir.

From the pollarded "candelabra" form of so many of the big old trees appearing to be the seed source of the present more or less pure deodar crops in many places (*e.g.* Naldhera, Pander Ridge, Dorus), it is evident that these crops have been established under or after a long period of intensive maltreatment of an earlier crop in which deodar was at least a major constituent. The fact that oak (usually *moru*) survives among the deodar as scattered intensively lopped trees of varying size suggests that oak may originally have been more abundant and even dominant. This possibility is often supported by the existence of a fringe of similar lopped oak between the edge of the forest and cultivation or settlement, but proof is lacking that the deodar is entirely invasive in oak forest ; on the right bank of the Jhelum where oak is absent this cannot have been so. We are accordingly of the opinion that although a considerable part of the area at present dominated by deodar even to the extent of practically pure crops, has the status of a secondary seral stage, it should be accorded climatic climax status over a significant proportion of the whole, just as with the *chir* pine. Its affinity to the dry deodar type (p. 326) may be noted together with the fact that it requires well drained soil. Where it is probably only seral in status, it seems likely that the climax will be the mixed coniferous forest with an admixture of oak and broadleaved trees dominating locally on appropriate soils and sites.

C1d. Western mixed coniferous forest

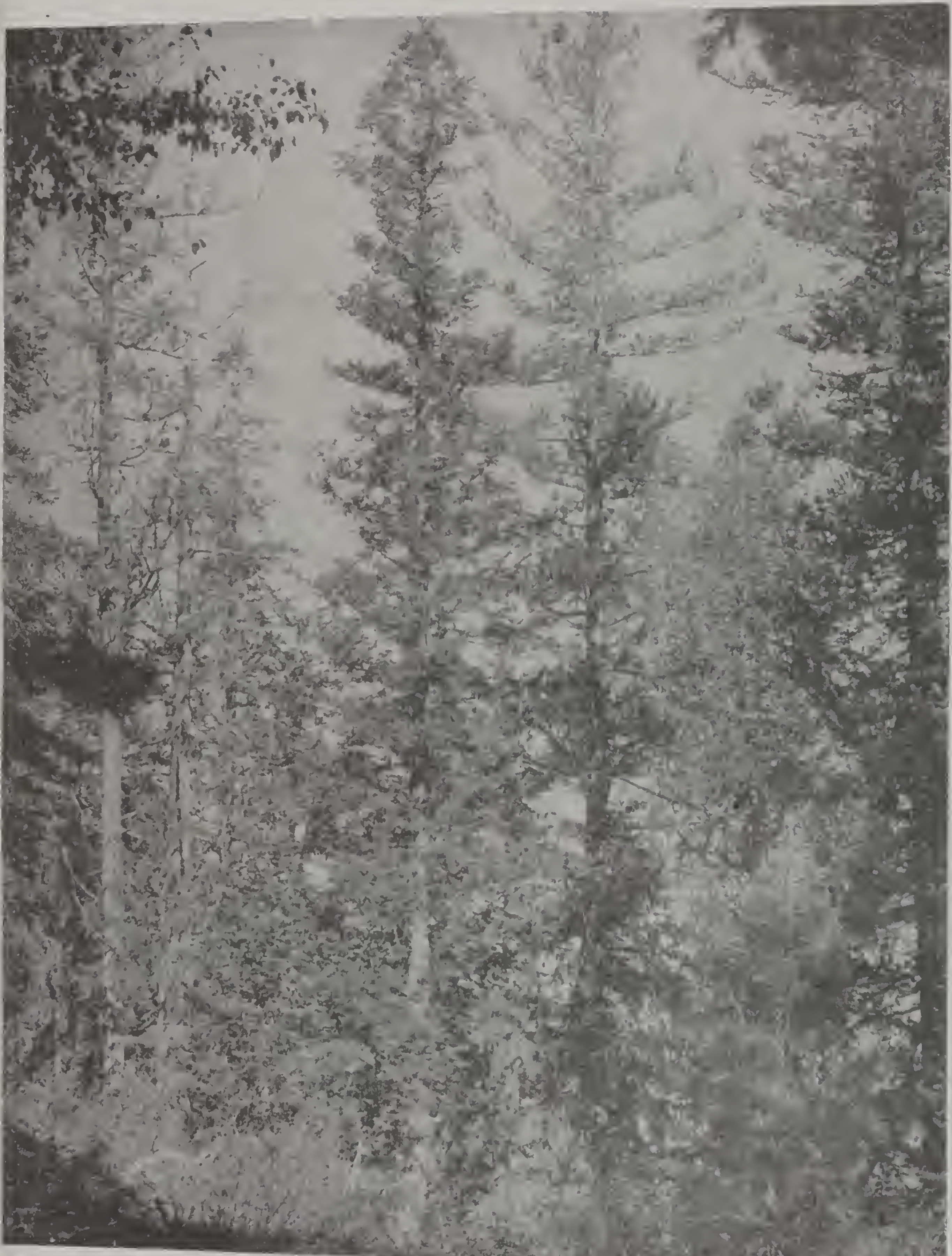
NOMENCLATURE.—This type is commonly referred to as mixed coniferous or simply "fir" forest but it also includes pure spruce and SURI's spruce and silver fir types (except his *Abies-Betula-Quercus* type). GORRIE's spruce formation and the upper part of OSMASTON's *Pinus-Cedrus* formation all fall within this type.

DESCRIPTION.—These forests are the most attractive in the Himalayas with a varying mixture of coniferous trees often of very fine growth, spruce, silver fir, blue pine and deodar, and a varying inter-mixture of evergreen and deciduous broadleaved trees and strips and patches of broadleaved forest. A height of 50 m. is by no means uncommon among the conifers and trees of very large girth are frequently met with. The tree canopy may be very dense and dark but varies greatly and is frequently broken by open grassy and flowery meadows mostly due to the slow but cumulative results of the use of these spots as grazing grounds ; these meadows usually carry scattered deciduous trees and the last surviving fir. In many areas, young trees are markedly deficient and regeneration is a problem. Patches of dwarf bamboos occur but are not general and the density of the undergrowth depends mainly on the intensity of the grazing. A rich herbaceous vegetation is developed during the monsoon, a variety of ferns being among the first to develop in the spring after the snow melts, and the shoots of *Strobilanthes* often predominating later ; this all dies off and is completely flattened down by the winter snow.

There is a good deal of moss and lichen on the trees but climbers are infrequent.

DISTRIBUTION.—The C. and W. Himalayas including N. W. Kumaon westwards through Jaunsar, Jammu & Kashmir.

LOCALITY FACTORS.—This type occurs mainly above the deodar forests at altitudes of about 2,400 to 3,000 m. or more, pure blue pine crops being found both in it and above and below, and the oak-fir type C2 above it.



WESTERN MIXED CONIFEROUS FOREST (HIGH LEVEL).
Abies spectabilis, *Pinus wallichiana* and *Betula utilis*, with shrubby undergrowth (2700 m.).
Hiranghatti, Upper Bashahr Division, Himachal Pradesh.

H. G. Champion

Rainfall usually varies between about the same limits as for the moist deodar, *i.e.*, from 1,140 mm. (or even 1,000 mm.) up to 1,300 mm., but the type also extends somewhat into still wetter localities though not in its most typical form. The data given for Kotgarh and Nagar may be taken as fairly representative.

Temperatures are as for the *Quercus dilatata* forest or rather cooler but detailed records are not available. Good snow fall is normal ; at the eastern limit of the range it does not lie for long but normally it should cover the ground for several weeks at least.

The forests occur on all types of rock. The soils are those typical of temperate coniferous forest as in Europe, usually with a well-developed "A" horizon and often with a considerable depth of undecomposed humus inimical to regeneration (cf. TAYLOR et. al., 1934).

A large proportion of the high level grazing stations are situated in this belt of forest and their presence exerts a far reaching influence on the ground vegetation and the regeneration of the tree species. SURI (1933) has recorded the variations in the depth of humus found with different types of undergrowth, from which it appears that the greatest depths are associated with the prevalence of *Rubus niveus* (10-30 cm.) and *Pteridium aquilinum* (25 cm.) in spruce forests, and *Strobilanthes atropurpureus* (7-10 cm.) in silver fir forest, regeneration being absent in all cases.

ILLUSTRATION.—Plate 82.

FLORISTICS.—The flora is practically identical with that described for the corresponding broadleaved forest of *Quercus dilatata*, except that the oak and all its associates are subordinated to a coniferous overwood to which some or all of spruce, deodar, blue pine and fir may contribute according to the altitude and other site factors.

(i) *Spruce-deodar belt, Sutlej Valley, Himachal Pradesh* (GORRIE)—

I. *Picea**, *Cedrus**, *Abies pindrow**, *Pinus wallichiana.*

II. *Quercus dilatata*, *Q. incana*, *Q. semecarpifolia*, *Acer acuminatum*, *A. caesium*, *A. pictum*, *Euonymus lacerus*, *Taxus baccata*, *Betula alnoides.*

IIa. *Arundinaria falcata*, *Thamnocalamus spathiflorus.*

III. *Deutzia corymbosa*, *Ribes rubrum*, *Viburnum nervosum*, *Skimmia*, *Strobilanthes* sp.

IVa. *Fragaria*, *Viola*, *Valeriana*, *Pteridium*, *Adiantum venustum*, *Aspidium aculeatum.*

IVb. *Oplismenus undulatifolius* and other grasses.

V. *Clematis barbellata*, *Hedera nepalensis*, *Schizandra grandiflora*, *Vitis* spp.

NOTE.—For further details, see GORRIE, 1933, pp. 33-38.

(ii) *Deoban, Chakrata, U.P.*, 2,440 m.—

I. *Abies pindrow** (a), *Picea smithiana** (f).

II. *Quercus semecarpifolia* (a), *Evonymus lacerus* (o), *Rhamnus purpureus* (r), *Meliosma dilleniaefolia* (r).

IIa. *Thamnocalamus spathiflorus.* (lf).

III. *Rosa macrophylla* (a), *Lonicera angustifolia* (a), *Strobilanthes wallichii* (f), *Smilax vaginata* (f), *Viburnum stellulatum* (f), *V. cotinifolium* (o), *Asparagus filicinus* (o), *Jasminum humile* (o), *Deutzia corymbosa* (lf).

IVa. *Viola serpens* (va), *Fragaria vesca* (a), *Ophiopogon* (a) *Polygonum speciosum* (a), *Impatiens* sp. (a), *Vicatia conii-folia* (f), *Valeriana hardwickia* (f), *Geranium wallichianum* (f), *Ainsluaea* (o), *Galium* (o), *Adiantum venustum* (f).

V. *Hedera* (a), *Vitis himalayana* (r), *Jasminum officinale* (o).

NOTE.—Preservation Plot No. 2, Chakrata Division (1913) at 2,500 m. on a northerly aspect of an intimate mixture of mature *Cedrus*, *Picea* and *Abies* with some *Q. dilatata*. Preservation Plot No. 30, Tons Division is a temple grove with fine trees of *Cedrus*, *Picea* and *Cupressus*.

(iii) *Grahan Nal, Parbatti Valley, Punjab. Abies-Picea-Cedrus type.* 2,150-2,900 m. (SURI).—

I. *Cedrus deodara** (a), *Abies pindrow** (a), *Picea smithiana**.

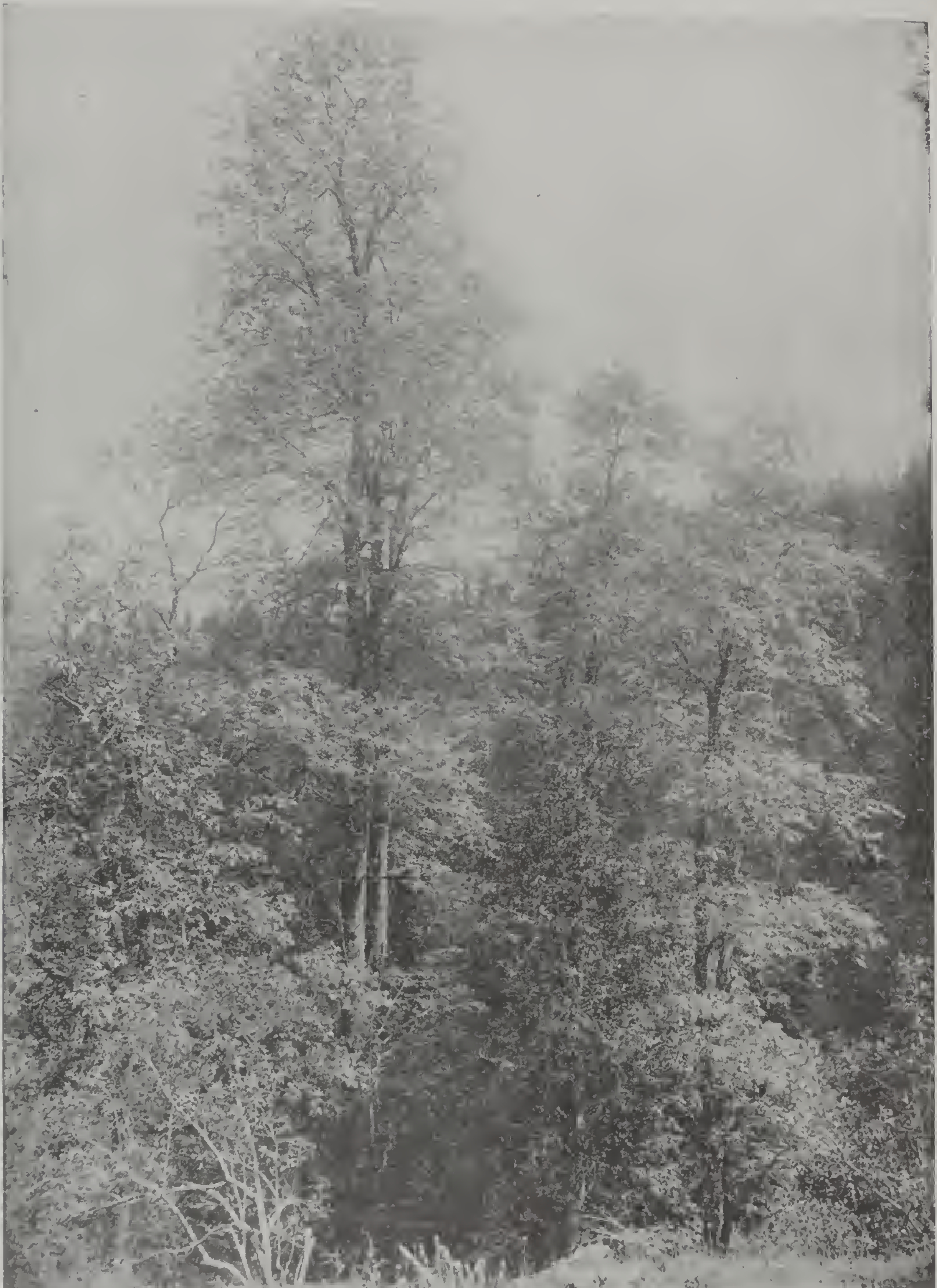
II. *Acer* spp., *Juglans regia*, *Corylus colurna*, *Celtis australis*, *Ulmus wallichiana.*

IIa. *Arundinaria falcata* (a), *Thamnocalamus spathiflorus.* (a).

III. *Strobilanthes* sp. (a).

NOTE.—SURI differentiated no less than ten subtypes according to the dominant species in the lower strata *e.g.*, hardwood, *Taxus*, *Arundinaria*, *Spiraea*, *Strobilanthes*, *Iris* bracken. These sub-types might somewhat influence the cultural operations necessary to ensure regeneration of the conifers, but their occurrence would appear to be due to varying soil and site conditions complicated by the nature and intensity of the biotic influences to which they had been subjected. AGGARWAL in his 1949 Working Plan for Kulu has followed him but reduced the number of subtypes to five.

ECOLOGICAL STATUS.—This mixed coniferous type appears to be a climatic climax though probably with a much higher proportion of broadleaved trees (evergreen oaks or deciduous species) than most of it now carries (PARKER 1942). MOHAN and PURI (1957) have collected data from a large number of sites in the Upper Sutlej Valley (Bashahr). They are definitely of opinion that "pure *Quercus semecarpifolia* community is the stable climax on all aspects and slopes" and that the "mixed oak-conifer bio-edaphic communities represent a secondary succession and always tend to develop to a stable pure oak community if and when the adverse biotic influences are removed". This succession is, however, admitted to be "exceedingly slow" on glacial moraines and on deep slopes and the evidence is far from conclusive that this is the correct explanation



MOIST TEMPERATE DECIDUOUS FOREST

Ulmus wallichiana (centre), *Acer* sp. etc. with *Cedrus deodara* (plantation) in background.
Mundali, Chakrata Division, Uttar Pradesh.

C. E. Parkinson

C1e. Moist temperate deciduous forest

DESCRIPTION.—A deciduous high forest, 20-30 m. high, the trees running to large girths though usually rather branchy, and the species occurring mixed singly or by groups of varying extent. The undergrowth is usually rather thin in undisturbed forest owing to the heavy shade when the trees are in leaf but the canopy is often broken enough to permit the growth of smaller trees and shrubs, also largely deciduous. Locally there may be gregarious growth of bamboos, but this is generally not developed.

DISTRIBUTION.—On suitable sites throughout the moist temperate forests except the lowest parts.

LOCALITY FACTORS.—This type is commonly found from 1,800 to 2,750 m. in moist hollows and depressions often as strips along the hill streams and also on many of the gentler slopes. It has been extensively cleared for cultivation or cattle steadings and has commonly suffered severely from proximity to settlements with the associated grazing, lopping and felling.

The type extends well into the dry temperate zone with very little change in composition, favourable soil conditions compensating for the drier climate. Local areas in the wet temperate E. Himalayan tract carry a very similar forest.

ILLUSTRATIONS.—Plate 83; TROUP, figs. 90 (*Aesculus*), 91 (*Acer*), 330 (*Juglans*).

FLORISTICS.—

(i) *Dwali, N. Almora Division, Kumaon, Uttar Pradesh* (OSMASTON).—

I. *Aesculus indica** (a), *Acer caesium** (a), *A. pictum* (f), *Carpinus viminea* (f), *Ulmus wallichiana* (f), *Betula alnoides* (o), *Juglans regia* (o), *Fraxinus micrantha* (r), *Quercus semecarpifolia* (o).

II. *Corylus colurna* (f), *Cornus macrophylla* (f), *Rhus punjabensis* (lf), *Taxus baccata* (o), *Prunus undulata* (o), *Euonymus lacerus* (f).

IIa. *Thamnocalamus spathiflorus* (lo), *T. falconeri* (lf).

III. *Viburnum foetens*, *Rubus repens*, *Berberis* spp., *Spiraea sorbifolia*, *Strobilanthes wallichii*.

IVa. *Paeonia emodi* (la), *Impatiens* spp., *Aconitum* sp., *Lilium giganteum*.

V. *Vitis semicordata*, *Clematis connata*, *Rubus lanatus*.

NOTE.—The Jaunsar forests are almost identical.

(ii) *Sutlej Valley, Himachal Pradesh* (GORRIE).—

I. *Acer caesium**, *A. pictum*, *A. villosum*, *Aesculus indica**, *Betula alnoides*, *Carpinus* spp., *Celtis australis*, *Fraxinus micrantha*, *Juglans regia*, *Pyrus lanata*, *Ulmus* spp., *Abies pindrow*, *Prunus cornuta*.

II. *Cornus* spp., *Corylus colurna*, *Euonymus tingens*, *Lyonia ovalifolia*, *Rhododendron arboreum*, *Rhus* sp., *Taxus baccata*.

IIa. *Arundinaria* spp.

III. *Berberis petiolaris*, *Cotoneaster* spp., *Deutzia corymbosa*, *Jasminum humile*, *Ribes* spp., *Sarcococca saligna*, *Strobilanthes atropurpureus*, *Viburnum* spp.

IVa. *Aconitum* spp., *Impatiens* spp., *Polygonatum* spp., *Spiraea vestita*, *S. aruncus*, *Aspidium* spp.

V. *Hedera nepalensis*, *Vitis semicordata*, *V. lanata*.

The Kulu forests are very similar.

(iii) *Pahalgam, Liddar Valley, Kashmir* ca 2,250 m.—

I. *Prunus padus**, *Aesculus**, *Corylus*, *Juglans**, *Acer caesium**, *Ulmus wallichiana*, scattered *Picea*, *Pinus wallichiana* and *Abies*.

II. *Euonymus hamiltonianus*, *Crataegus oxyacantha*.

III. *Viburnum* spp., *Parrotia*.

Small consociations of the several species are frequently met with.

(iv) *Jhelum Valley, Kashmir.*—

It is probable that the floor of the valley formerly carried broadleaved forest including *Ulmus villosa*, *Celtis*, *Juglans*, *Prunus padus*, *Fraxinus* with *Salix wallichiana* and *Populus ciliata* along the streams.

ILLUSTRATIONS.—TROUP, Figs. 328—330.

General Notes.—It remains a matter of opinion whether this type should be viewed as a climatic climax with a varying admixture of conifers (often largely confined to the better drained sites, where they may dominate), or an edaphic climax on the moister soils and sites within a conifer-dominated climax. PARKER (1942) while admitting the infrequency of fir on the gentler slopes, which may carry purely broadleaved forest, seems to take the view that the latter is an edaphic variant of a climax type consisting of mixed broadleaved and coniferous trees, the mixture in some as yet unknown way making it possible for both groups to maintain their place by natural regeneration.

In the E. Himalayas, patches of predominantly deciduous forest occur in the wet temperate forest which are obviously closely related to the western form here described. Further study is needed.

SURI (1933) points out that deciduous forest also colonises new landslips in cold sites unsuitable to blue pine.

C1f. Low-level blue pine forest (P. wallichiana)

Many foresters have treated the extensive more or less pure *kail* forests occurring in the *ban* oak, *moru* oak, and mixed coniferous zones as a separate type in its own right, and certainly their management calls for quite different techniques. It is, however, now generally accepted that such forests are all secondary to the destruction of pre-existing forest of various types from natural or biotic causes. *Pinus wallichiana* is the universal coloniser of vacant sites. Whilst under natural conditions it can maintain itself in the broadleaved and coniferous forests in chance gaps caused by wind, snow or landslip, its occurrence over large areas is only made possible by human disturbance ; its profilic and regular seeding is an important factor. Accordingly these *kail* forests cannot be accorded climax status and are described on pp. 320-321 as a secondary seral type and on p. 320 as a primary seral type on new riverain soils.

C1/DS1. Oak scrub

Practically all the oak forests are subject to heavy grazing and in the absence of special protective measures, equally heavy lopping. The older trees usually succumb but the smaller tend to become reduced to coppice scrub, often practically pure oak as most associated species are more easily killed, but *Rhododendron arboreum* and *Lyonia ovalifolia* being both unpalatable to stock and poor fuels are generally left. At the lower elevations *Pyrus pashia* often survives perhaps owing to its thorniness. *Q. dilatata* tends to be lopped to the main stem and stands in columnar form till it is killed so that most of the scrub is *Q. incana* and locally *Q. semecarpifolia.*

C1/DS2. Himalayan temperate secondary scrub

DESCRIPTION.—An irregular but often dense and extensive scrub cover with a few species predominating, and sometimes scattered residual trees of the original forest or pioneers of the secondary sere.

DISTRIBUTION.—Throughout the temperate forest on the site of abandoned shifting cultivation, on burnt areas especially on southern aspects, on excessively grazed and lopped areas near villages, and on other similar sites.

LOCALITY FACTORS.—The secondary nature of most of these scrub communities is evident and ascribable to the cause mentioned. Their stability varies greatly with conditions, from those which can quickly revert to forest on removal of the retrogressive influences to others where progression is so slow as to be hardly apparent—this is particularly applicable to hot southern aspects at the middle and lower elevations.

FLORISTICS.—

(i) *Quercus incana forest, Nainital Division, U.P.*, 1,800 m.—
Plectranthus rugosus, Berberis asiatica, Crataegus crenulata.*

NOTE.—This is a dry type also occurring in the dry temperate forests.

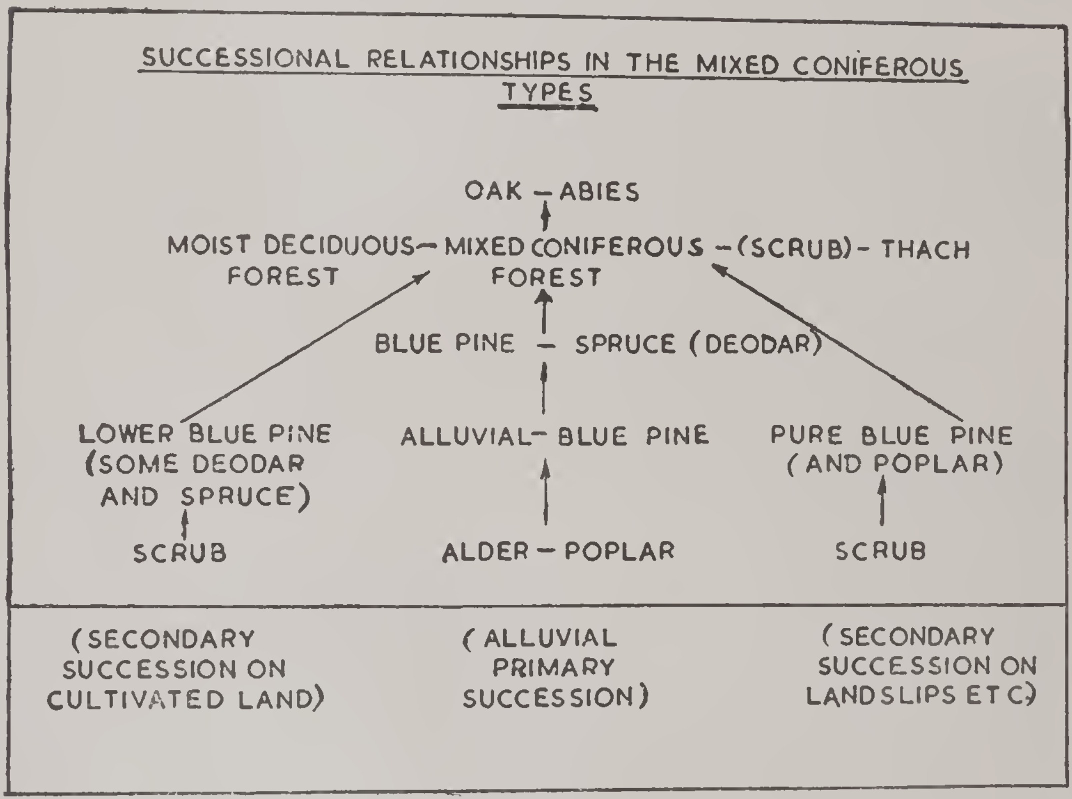
(ii) *Quercus incana forest, W. Almora Division, U.P.* 2,000 m.—
I. *Berberis lycium*, Spiraea canescens, Prinsepia utilis, Indigofera gerardiana, Crataegus crenulata, Pyrus pashia.*

(iii) *Quercus dilatata-Deodar forest, Jaunsar*, 2,150 m.—
Indigofera gerardiana, Cotoneaster bacillaris, Berberis lycium, Rosa macrophylla*, etc.

(iv) *Eastern oak-hemlock, near Tal La, Sikkim,* 2,150 m.—
*Piptanthus nepalensis** (va), *Rosa sericea** (va), *Berberis* spp. (f), *Elsholtzia* spp. (f).

NOTE.—The first two species greatly predominate and form a closed thicket about 2 m. high.

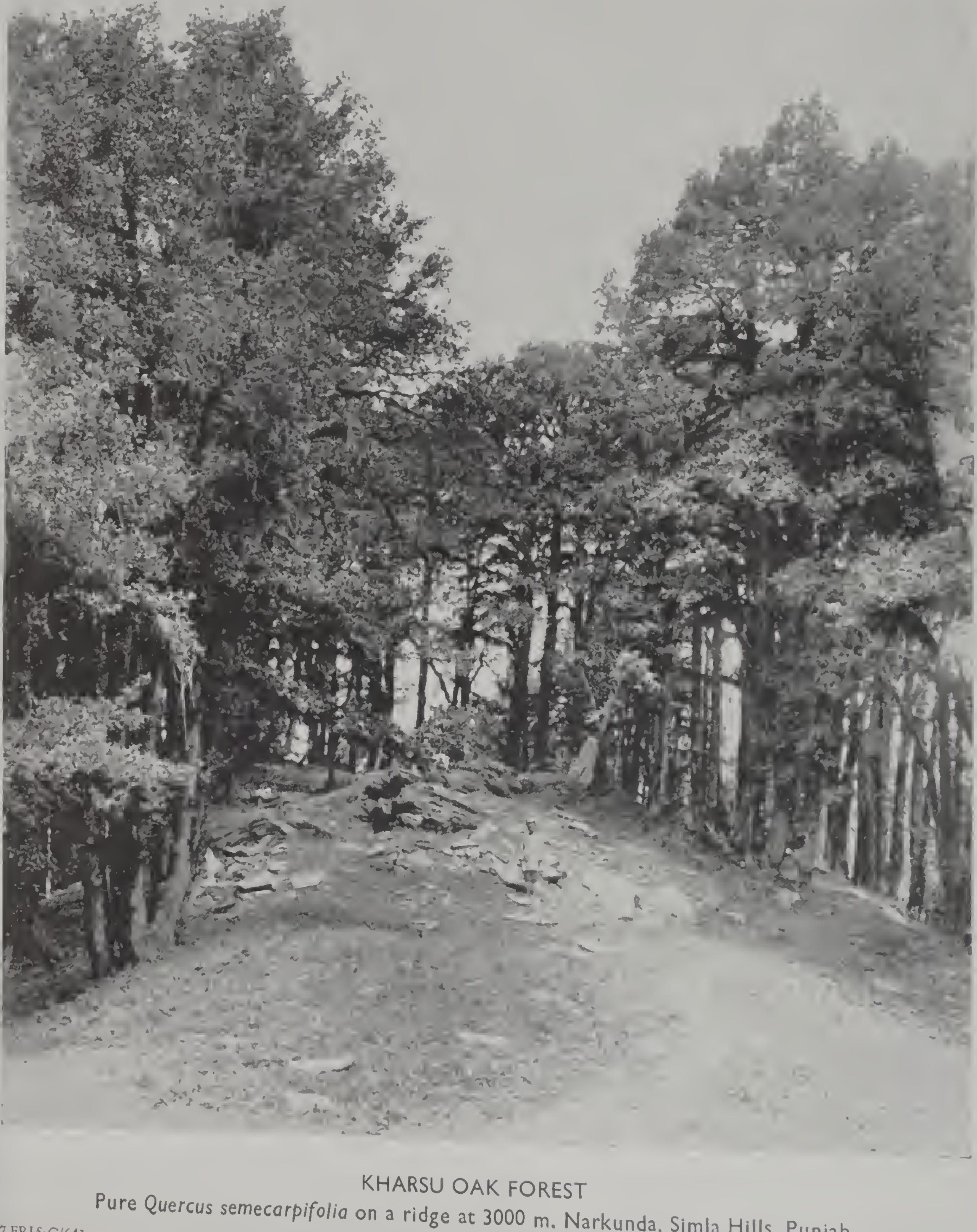
Typical successional phases are indicated in the following scheme :—


SUCCESSIONAL RELATIONSHIPS IN THE MIXED CONIFEROUS TYPES
OAK – ABIES
MOIST DECIDUOUS FOREST – MIXED CONIFEROUS FOREST – (SCRUB) – THACH
BLUE PINE – SPRUCE (DEODAR)
LOWER BLUE PINE (SOME DEODAR AND SPRUCE)
ALLUVIAL – BLUE PINE
PURE BLUE PINE (AND POPLAR)
SCRUB
ALDER – POPLAR
SCRUB
(SECONDARY SUCCESSION ON CULTIVATED LAND)
(ALLUVIAL PRIMARY SUCCESSION)
(SECONDARY SUCCESSION ON LANDSLIPS ETC)

C2. Upper West Himalayan temperate forests

C2a. Kharsu oak (Quercus semecarpifolia)

DESCRIPTION.—The oak forms a dense crop about 15—20 m. rarely 30 m. high with very little admixture of other species. The trees are hung with dark green-brown moss. A second tree storey is often absent but dense brakes of dwarf bamboo are a marked feature in many places though sometimes missing, particularly on southern aspects. There is very generally a ground-cover of mostly deciduous shrubs with a varying amount of grass, ferns and herbaceous growth. Scattered silver fir occur and sometimes some blue pine and spruce, and in sheltered sites the oak is displaced by the fir forest. At the top of the altitudinal range it merges into the sub-alpine forests of fir, *Rhododendron* and birch, but it often abuts directly on the alpine pastures.



KHARSU OAK FOREST

Pure *Quercus semecarpifolia* on a ridge at 3000 m. Narkunda, Simla Hills, Punjab.

T. V. Dent

DISTRIBUTION.—All along the outer and moister ranges of the W. and C. Himalayas (except in Kashmir) between about 2,500 m. and 3,300 m., particularly on southern aspects and scarp slopes.

LOCALITY FACTORS.—No climatological data are available but heavy snowfall is usual, and the summer is short and largely coincident with the monsoon rainfall. The oak only comes into new leaf late in May and frosts occur at the end of September. Hail storms are common in April-May and often strip the old foliage.

ILLUSTRATION.—Plate 84.

FLORISTICS.—

(i) *Dhakuri, C. Almora Division, Kumaon.* 2,900 m. N. aspect.—

I. *Quercus semecarpifolia** (va), *Betula alnoides* (o), *Pyrus lanata* (f), *Quercus dilatata* (o), *Acer caesium* (o), *Abies pindrow* (lf).

II. *Meliosma dilleniaefolia* (o), *Rhododendron arboreum* (f), *R. barbatum* (o), *Sorbus foliolosa* (o), *Betula utilis* (o).

IIa. *Thamnocalamus spathiflorus* (va), *Thamnocalamus falconeri* (f).

III. *Rosa sericea* (f), *R. macrophylla* (f), *Viburnum foetens* (a), *Cotoneaster acuminata* (f), *Strobilanthes wallichii* (f), *Ribes glaciale* (o), *Salix elegans* (f).

IVb. The typical grasses have been listed by MOHAN (1955) and SETH (1954).

V. *Clematis montana*, *Vitis himalayana*, etc.

(ii) *Garhwal Himalaya*, 3,350 m., S. E. aspect. (OSMASTON).—

I. *Quercus semecarpifolia** (va), *Abies pindrow* (o), (21—24 m.).

II. *Rhododendron arboreum* (a), (7-10 m.), *Prunus padus* (o), *Ilex dipyrena*, *Acer* spp., *Taxus baccata*.

IIa. *Thamnocalamus spathiflorus* (va), *Arundinaria jaunsarensis* (va).

III. *Rosa sericea*, *R. macrophylla*, *Cotoneaster acuminata*, *Salix elegans*, *Ribes glaciale*, *Strobilanthes atropurpureus*, *Viburnum foetens*, *V. stellulatum*, *V. cotinifolium*.

IVa. Discontinuous growth of mostly perennial herbs; mosses and ferns abundant.

IVb. Occasional tufts of grass.

V. Few deciduous lianas.

(iii) *Deoban, Chakrata, Jaunsar, U. P.* (7 *Sample Plots*) *Preservation Plot No.* 23 (1939).

I. *Quercus semecarpifolia** (a), *Picea smithiana* (o), *Meliosma dilleniaefolia* (r), *Abies pindrow* (r).

II. *Euonymus tingens* (o), *E. lacerus* (o), *Cotoneaster acuminata* (f), *Prunus padus* (o), *Ilex dipyrena* (o), *Viburnum stellulatum* (f), *V. foetens* (o), *V. cotinifolium* (o).

IIa. *Thamnocalamus spathiflorus* (lf).

III. *Rosa macrophylla* (a), *Lonicera angustifolia* (a), *Jasminum humile* (f), *Rubus niveus* (a), *Smilax vaginata* (f), *Elsholtzia* (o), *Sarcococca* (f), *Berberis* spp. (f), *Rhamnus purpureus* (o), *Strobilanthes wallichii* (f), *Skimmia laureola* (lf).

IVa. *Polygonum speciosum* (a), *Senecio rubricaulis* (a), *Fragaria vesca* (a), *Geranium wallichianum* (f), *Viola* spp. (a), *Valeriana hardwickii* (f), *Crepis* spp. (f), *Polygonatum verticillatum* (f).

(iv) *Daranghati, Bashahr, Himachal Pradesh*, 2,805 m.
(MOHAN and PURI)

I. *Quercus semecarpifolia* (aa), *Picea smithiana* (f), *Pinus wallichiana* (o).

II. *Rhododendron arboreum* (f), *Ilex dipyrena* (o), *Prunus padus* (o).

III. *Cotoneaster bacillaris* (f), *Viburnum cotinifolium* (f), *Rosa macrophylla* (o).

IVa. *Geranium wallichianum* (a), *Fragaria vesca* (a), *Rumex* spp. (a), *Viola canescens* (f), *Anemone rivularis* (f), Ferns (a).

IVb. Grasses (a).

Ecological Note.—It was observed in the *kharsu* forest near Kadrala, Himachal Pradesh, that the *Abies* seemed unable to penetrate the oak canopy where dense, even after reaching the lower level of the crown, though it could continue to grow under heavy shade and get through any small gap. Regeneration of the oak is often in dense thicket form in which it would be difficult for the conifer to establish itself. Whilst this observation supports the oak climax view, it may equally well be restricted to those parts of the general site that are particularly favourable to the oak or unfavourable to the fir.

C2b. West Himalayan Upper oak—fir forest

NOMENCLATURE.—This type is very generally already well known as the oak-fir forest (OSMASTON), but this descriptive term is often taken to include the upper birch-fir forest which extends up to the timber limit and is here distinguished as sub-alpine forest. SURI's *Abies-Betula-Quercus* type and GORRIE's *Silver fir-kharsu oak* are both included in part.

DESCRIPTION.—Typically a two storeyed high forest with the silver fir standing singly or in strips and groups over oak and other evergreen and deciduous trees, the two canopies together forming a fairly complete cover. There is always more or less shrub growth over the soil and a luxuriant herbaceous growth during the summer except where too dense and dark. Bamboo is locally abundant but often absent. Climbers are relatively few, but the oaks carry a conspicuous mantle of mosses.

DISTRIBUTION.—Along the higher ranges of the W. and C. Himalayas eastwards to Nepal, between 2,600 and 3,400 m. especially on northern aspects and sheltered sites. It lies above the mixed coniferous forest too high for deodar though spruce may occur.

LOCALITY FACTORS.—No climatological data are available. The sites occupied are under snow for several months in the winter. The drier warmer sites between the zonal limits mentioned tend to be occupied by pure oak forest but the type persists into regions with a lower rainfall, melting snow ensuring the presence of adequate moisture supplies. Fire is of exceptional occurrence but far-reaching in its effects; it checks the fir to the benefit of deodar and blue pine (cf. for instance, TREVOR, Working Plan for Kulu division 1919, para. 74). Grassy meadows are typical and more extensive than in the lower zone and often join up with the true alpine pastures above tree-limit. A deep moist humus layer is usually present.

FLORISTICS.—

(i) *Dhakuri, S. Almora Division, U. P.* 3,000 m.—

I. *Abies pindrow** (a).

II. *Quercus semecarpifolia* (a), *Q. dilatata* (f), *Pyrus lanata* (f), *Rhododendron arboreum* (f), *R. barbatum* (lf), *Sorbus foliolosa* (o).

IIa. *Arundinaria jaunsarensis* (lf), *Thamnocalamus spathiflorus* (lf).

III. *Rosa macrophylla* (f), *Viburnum foetens* (la), *Berberis vulgaris* (f), *Strobilanthes* sp. (a), *Smilax vaginata* (f).

(ii) *Garhwal Himalaya (moist)*. (OSMASTON).—

I. *Abies pindrow**, *Picea smithiana* (r).

II. *Quercus semecarpifolia**, *Q. dilatata*, *Ulmus wallichiana*, *Aesculus indica*, *Acer caesium*, *Corylus colurna*, *Taxus baccata*.

IIa. *Thamnocalamus spathiflorus*, *Arundinaria jaunsarensis*.

III. *Strobilanthes* spp., *Rubus niveus*, *Sarcococca pruniformis*, *Wikstroemia canescens*, *Rosa macrophylla*, *Skimmia laureola*, *Syringa emodi*, *Viburnum* spp.

V. *Vitis semicordata*, *Schizandra grandiflora*, *Hedera nepalensis*.

(iii) *Deoban, Chakrata Division, Jaunsar (cf. Sample Plot* 45)—

I. *Abies pindrow**, *Picea smithiana* (r).

II. *Quercus semecarpifolia** (o), *Q. dilatata* (r), *Acer caesium* (o), *Meliosma dilleniaefolia* (r), *Euonymus lacerus* (r), *Ilex dipyrena* (r).

IIa. *Thamnocalamus spathiflorus* (r).

III. *Rosa macrophylla* (a), *Rubus niveus* (a), *Lonicera angustifolia* (r), *Smilax vaginata* (a), *Viburnum stellulatum* (f), *Strobilanthes* spp. (f), *Berberis* spp. (o), *Asparagus filicinus* (o), *Viburnum foetens* (o), *Salix elegans* (r), *Rhamnus purpureus* (r), *Jasminum humile* (r).

IVa. *Ainsliaea aptera* (a), *Ophiopogon* (a), *Polygonum speciosum* (a), *Valeriana hardwickii* (f), *Podophyllum hexandrum* (f).

V. *Clematis* spp. (o), *Vitis semicordata* (o), *Hedera* (a).

(iv) *Pulga, Parbati Valley, Kulu, Punjab.* 2,600—2,750 m. —

I. *Abies pindrow** (a), *Pinus wallichiana* (lf), *Picea smithiana* (lo).

II. *Acer* spp. (o), *Taxus baccata* (o), *Corylus colurna* (o), *Quercus semecarpifolia** (o), *Pyrus lanata* (o).

III. *Rosa sericea* (f), *R. macrophylla* (f), *Viburnum foetens* (la), *Rubus niveus* (a), *Smilax vaginata* (f), *Spiraea* spp. (o), *Berberis* spp. (f), *Indigofera gerardiana* (f), *Strobilanthes wallichii* (la), *Viola serpens* (f).

IVa. *Fragaria vesca* (f), *Ainsliaea aptera* (f), *Valeriana wallichii* (f), *Galium asperifolium* (f), *Adiantum venustum* (la).

(v) *Sutlej Valley* (GORRIE).—

I. *Abies pindrow**.

II. *Quercus semecarpifolia**, *Betula alnoides, B. utilis, Acer* spp., *Sorbus foliolosa.*

IIa. *Arundinaria* spp.

III. *Spiraea bella, Cotoneaster acuminata, Rhododendron campanulatum, Strobilanthes* spp., *Viburnum nervosum.*

IVa. *Fragaria vesca, Podophyllum hexandrum, Senecio* spp., *Spiraea* spp.

V. *Vitis semicordata, Schizandra grandiflora.*

GENERAL NOTE.—As a rule the silver fir forest would appear to be a true climatic climax. GLOVER (1931) and SURI (1933) suggested, however, that in their view, it is not able to maintain itself; an understorey of *Taxus* becomes established in which it cannot regenerate, and when in time the overmature trees decay and fall, a new succession takes place from a shrub association to the temperate deciduous forest under which spruce and fir again become establisied. In this connection, PARKER (1942) adduced evidence supporting his view that the climax type is an intimate mixture of silver fir and broadleaved species; the conditions for regeneration have been fundamentally altered by the very heavy grazing and lopping to which the forests have been subjected, particularly early in the season before the herbaceous growth has developed. It will be noted that the typical form or species of fir here is *Abies pindrow, A. spectabilis* replacing it in the sub-alpine forests above (cf. RAIZADA, 1960).

C2c. Moist temperate deciduous forest

This type has already been described on p. 307.

C3. East Himalayan moist temperate forest

This type is subdivided for convenience into two subtypes, *viz.*,

(a) East Himalayan mixed coniferous forest.

(b) *Abies delavayi* forest.

C3a. East Himalayan mixed coniferous forest

NOMENCLATURE.—*Rhododendron-Tsuga-Abies hylium* of BOR.

DESCRIPTION.—A dense evergreen forest, with oak and *Rhododendron* predominating but with groups of hemlock of varying extent on the drier ridges. The hemlock gradually gives way to silver fir at the higher elevations and the transition to the wet temperate forest is very gradual. With the oak are mixed deciduous trees such as *Magnolia, Acer, Betula* to a varying extent. There is usually a dense undergrowth, most usually of bamboo, and in its absence, of *Rhododendron* spp., and other evergreen shrubs. Most of the trees are hung with epiphytic mosses and other epiphytic growth is also abundant.

DISTRIBUTION.—From the Sikkim Himalaya (except outermost ranges) eastwards to the Mishmi Hills, NEFA, and westwards into Nepal with a possible outlier in E. Almora, U. P., where pure hemlock forests occur in some blocks.

LOCALITY FACTORS.—The altitudinal zone occupied is about 2,300 to 3,000 m. rather higher than that of the western form equated with the present one.

Rainfall data are not available, but it is estimated to be between 1,250—2,000 mm. The figures given for Kalimpong illustrate its seasonal distribution; the monsoon breaks earlier than in the west and continues longer, but the winter months are drier.

Temperature data are likewise not available. The Darjeeling figures (p. 284) refer to approximately the right altitude but must reflect the effects of heavier rainfall and the many rainy days (p. 285).

The Sikkim grazing grounds seem to be more in the fir zone than in the hemlock but the forests have suffered a good deal from shifting cultivation and fires, the latter encouraging the spread of *Arundinaria*.

ILLUSTRATIONS.—cf. Plate 99; TROUP, Figs. 483 (*Tsuga*), 473 (*Abies*).

FLORISTICS.—

(i) *Ramam Darjeeling Division, W. Bengal (Sample Plots and Preservation Plot* No. 11, 2,750 m.)—

I *Tsuga dumosa** (a), *Abies densa* (o).

II. *Quercus pachyphylla**(a), *Q. lineata* (f), *Acer campbellii* (o), *Magnolia campbellii* (r), *Betula utilis* (r), *Taxus baccata* (r), *Rhododendron arboreum* (a), *R. grande* (o), *Brassaiopsis alpina* (r), *Symplocos phyllocalyx, Acer pectinatum.*

IIa. *Arundinaria malinga?* (va).

III. *Daphne cannabina* (f), *Rubus niveus* (f), *Berberis aristata* (f), *Piptanthus nepalensis* (lf).

IVa. Ferns abundant.

NOTE.—Some of the *Tsuga* are over 6 m. in girth.

(ii) *Below Sandakphu, Darjeeling Division, W. Bengal (Sample Plot* 21 *and Preservation Plot* 13)*—at* 3,500 m.

I. *Abies densa**.

II. *Rhododendron arboreum* (f), *R. cinnamomum* (f), *R. barbatum* (o), *R. hodgsoni* (o), *Betula utilis* (o).

IIa. *Thamnocalamus aristatus** (va).

III. *Rosa sericea* (f), *Berberis aristata* (a), *Rubus* spp. (a).

IVb. Some "*lekh dubo*" grass.

NOTE.—The area described is near the top limit of the type where oaks have practically dropped out.

GENERAL NOTE.—This oak-conifer type appears to occupy a position midway between the wet and moist temperate types as it is found in the middle ranges apparently still too moist to permit of the occurrence of *Pinus wallichiana* and spruce, but the *Tsuga* extends well into the dry inner valleys with the spruce as in the Lachen V (SHEBBEARE 1934).

C3b. Abies delavayi forest

ILLUSTRATION.—Plate 85.

FLORISTICS.—

Balipara Frontier tract, Assam (BOR)—

I. *Abies delavayi** (a).

II & III. *Rhododendron falconeri, R. barbatum, R. hodgsoni, R. filgens, R. keysii, R. maddeni, Lyonia ovalifolia, Litsea sericea.*

IIa. *Thamnocalamus aristatus.*

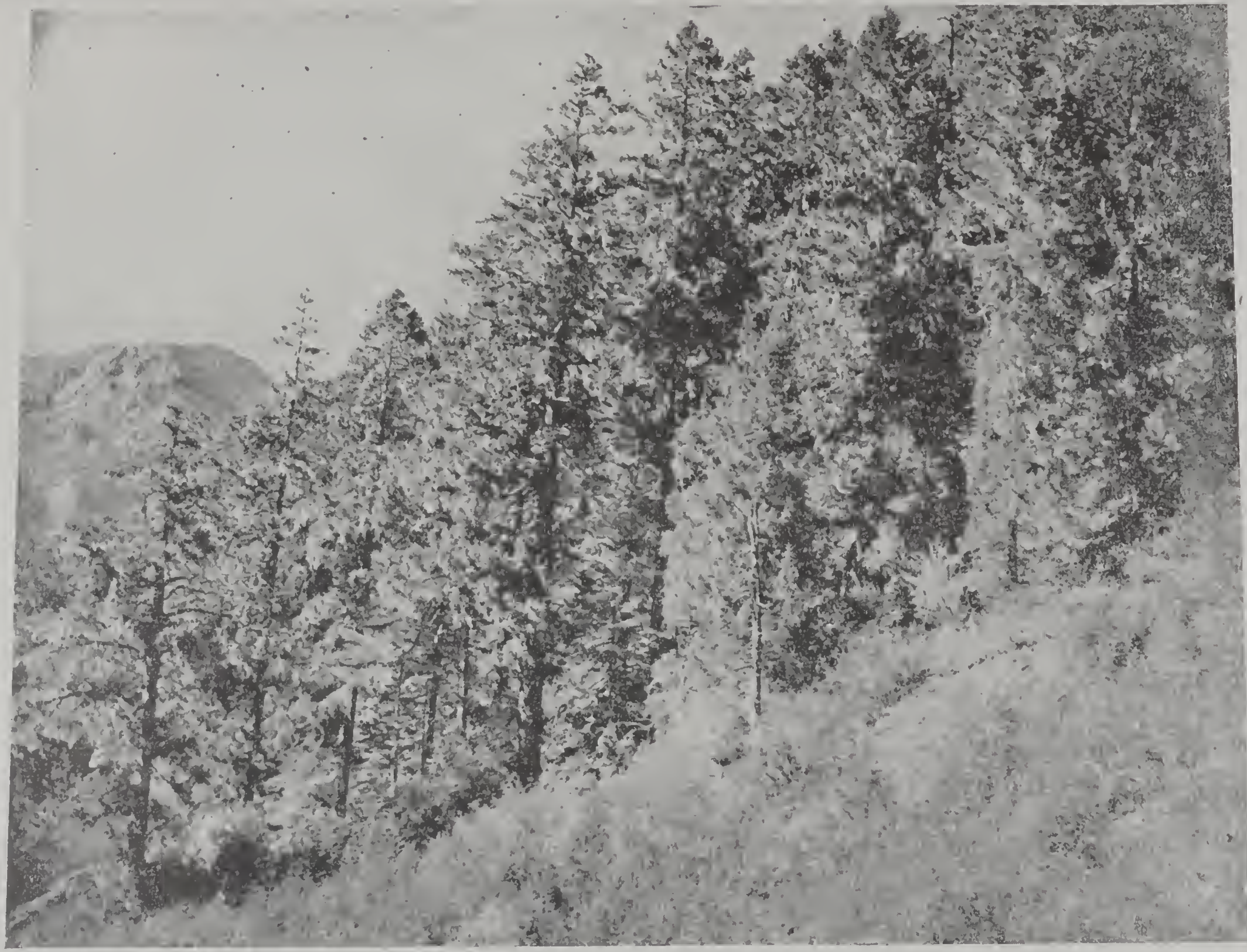
NOTE.—*Abies delavayi*, a Chinese species common in Szechuan, occurs in remarkably pure stands, confined to the northern slopes of Piri between 2,750—3,350 m. It is upto 20 m. tall and attains a girth of 2 m.

DEGRADATION STAGES OF HIMALAYAN MOIST TEMPERATE FORESTS

DS1. Montane bamboo brakes

NOMENCLATURE.—Mountain Bamboo brake, *Ringal* (W. Himalaya), *Maling* (E. Himalaya).

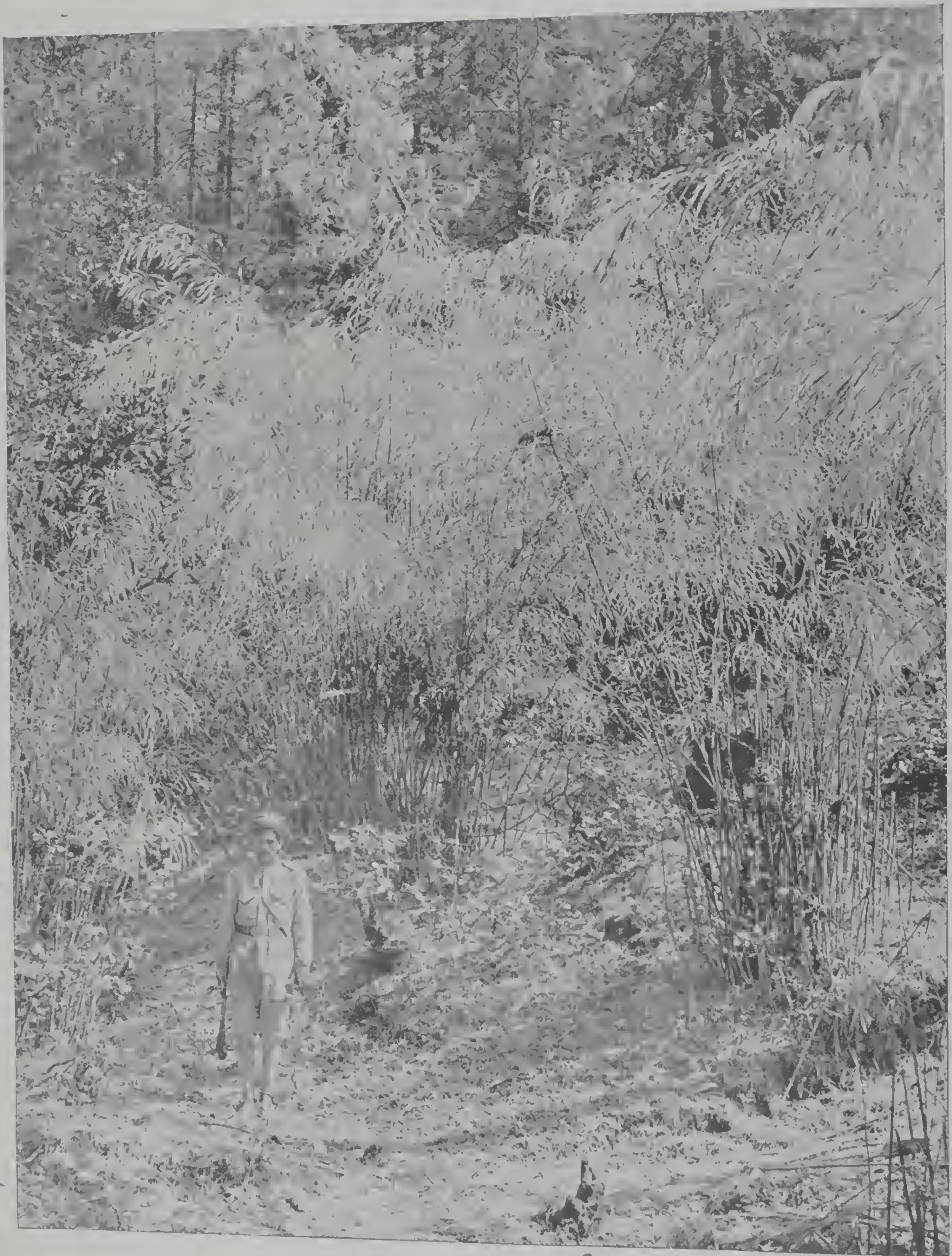
DESCRIPTION.—Dense, almost impenetrable brakes of one or more species of *Arundinaria* and related genera and often practically no other large woody plants. In the damper regions there may be much epiphytic moss on the older bamboos. A herbaceous flora covers the soil wherever enough light penetrates. Transitions with a scattered overwood are numerous.



ABIES DELAVAYI FOREST

Pure *Abies delavayi* association. Balipara Frontier Tract, N.E.F.A.

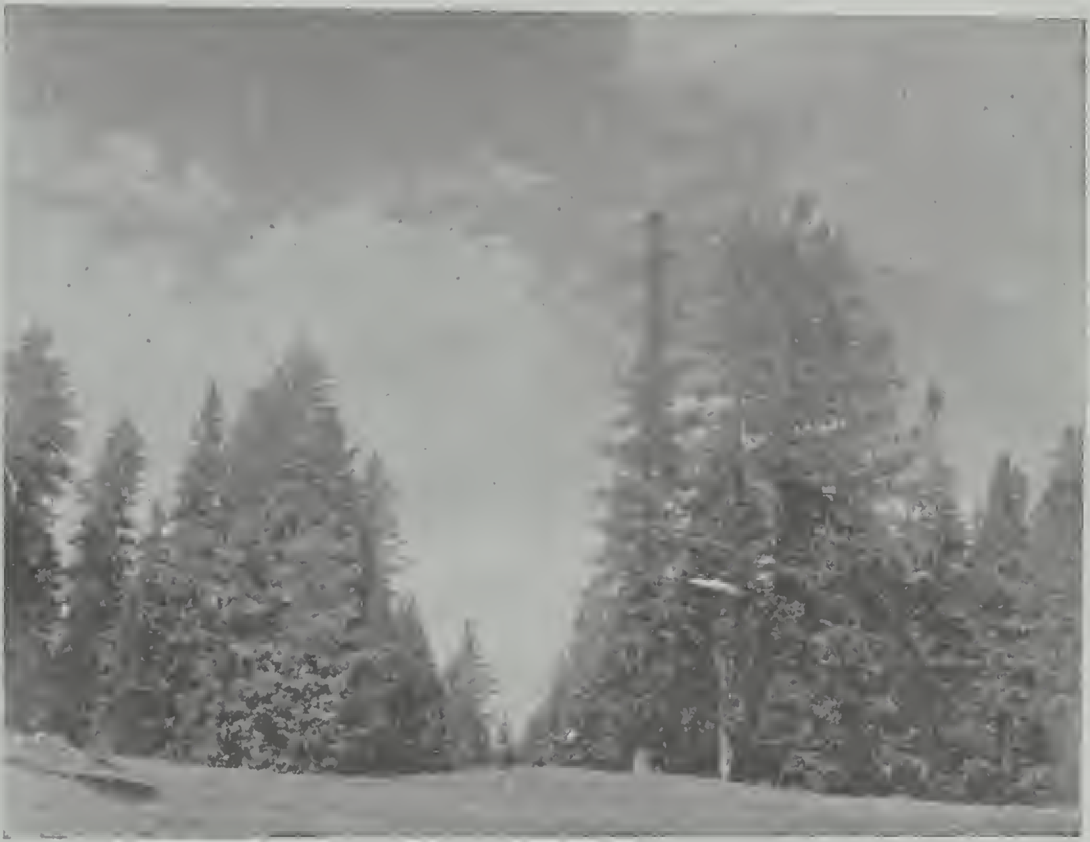
R. N. Loganey



MONTANE BAMBOO BRAKES

Dense *Arundinaria* spp. in fir forest and preventing its regeneration. Baghi, Lower Bashahr Division, Himachal Pradesh.

A. L. Griffith



HIMALAYAN TEMPERATE PASTURES

Mature *Abies pindrow*, *Pinus wallichiana*, *Picea smithiana* with *Quercus semecarpifolia* at edge of pasture. Bharach Thach, Jubbal, Himachal Pradesh.

H. G. Champion

DISTRIBUTION.—Throughout the moist temperate forests of the Himalaya from E. Punjab to the N. E. Frontier and also in the Nilgiris.

LOCALITY FACTORS.—The high level bamboos are commonly present as an underwood to the climax oak, *Rhododendron*, and coniferous forests above about 2,400 m. but have undoubtedly been exterminated by cutting and grazing in many localities. In the less frequented forests however they often take complete possession of the ground where the tree canopy is broken from whatever cause and effectively check tree regeneration. In many parts of the E. Himalayas, burning is an important factor particularly after the bamboo has flowered and died as fires sweep up the slopes killing the standing trees both broadleaved and coniferous and pure bamboo brake results.

ILLUSTRATION.—Plate 86.

NOTE.—There are extensive areas of this type in Darjeeling district (cf. COWAN) and in the North East (cf. BOR) mainly due to fires.

DS2. Himalayan temperate parkland

DESCRIPTION.—Open parklike land with scattered large, misshapen and often moribund trees of the species typical of the temperate deciduous forest with or without coniferous trees also, over a grassy turf full of flowers in spring, and often with browsed clumps of *Berberis*, *Lonicera*, *Arundinaria*, *Cotoneaster*, or patches of inedible shrubs such as *Viburnum foetens* and herbs such as *Iris* and *Osmunda*.

DISTRIBUTION.—Thoughout the upper, the middle, and uppermost part of the lower oak forests of the Himalaya.

LOCALITY FACTORS.—Derived from the temperate deciduous forest, and probably extended into the associated coniferous types by grazing and its concommitants, lopping, barking and burning, which have thinned out the forest to a varying degree, destroyed all undergrowth except for patches of inedible species, and replaced the shrub by ground cover by a close grassy turf. Although surface denudation is slight, the soil structure is altered by exposure, treading and the presence of the grass mat, and especially where clayey it is generally rendered unfavourable to tree regeneration. At the higher elevations the increased exposure to wind and cold and the greater accumulation of snow are also factors inimical to recolonisation by tree species. The locally heavy manuring by cattle dung also has a marked effect on the composition of the ground flora.

ILLUSTRATION.—Plate 87.

FLORISTICS.—*Prunus padus* (*P. cornuta*) is very characteristic as it is less lopped than the other trees, and *Acers* are usually among the last survivors. Walnut is frequent in the northwest.

Dense growth of *Rumex nepalensis* marks the site of sheep and cattle pens.

GORRIE (1933) lists the species occurring in this type and the original mixed deciduous forest (*loc. cit.* pp. 39—42). SETH (1954) lists the common grasses.

DS3. Himalayan temperate pastures

Where grazing has taken place in the temperate forests, favourable sites on ridges and the greater slopes especially where moist or near water, have gradually been cleared passing through the Parkland stage to open grassland.

AGARWAL (1959) has made a study of these Himalayan grasslands as represented in Jaunsar, Uttar Pradesh, and lists the following grasses as common in the mixed coniferous forest zone—*Festuca* spp., *Agrostis* spp., *Calamagrostis* spp., *Dactylis glomerata*, *Bromus* spp., *Danthonia* spp., and many others. Lower down in the deodar and ban oak forests, these grasses are mixed with tropical species, notably *Themeda*, *Heteropogon*, *Chrysopogon* etc. Also see SETH (1954).

ILLUSTRATION.—Plate 87.

SUBSIDIARY EDAPHIC AND SERAL TYPES OF HIMALAYAN MOIST TEMPERATE FORESTS

E1. Cypress forest

DESCRIPTION.—Typically very open forest of scattered trees on steep rocky ground with xerophytic shrubs and little grass, the trees being 10—25 m. high and branchy to the base. It is capable, however, of excellent growth with a height up to 45 m. and may form an uneven but fairly closed wood with a filling and second storey of oak and other evergreens, or more or less bamboo.

DISTRIBUTION.—Throughout the outer and middle ranges of the Himalaya from Chamba (H.P.) to the Aka Hills (NEFA) at 1,800 to 2,800 m., rarely in extensive blocks.

LOCALITY FACTORS.—Cypress forest is most frequently met with on limestone rocks which provide relatively dry soil conditions, particularly on screes of limestone shales. It is very sensitive to fire which may be influential in determining its distribution and provide a reason why it is limited to steep ground without much grass growth except where a mesophytic evergreen undergrowth protects it (Naini Tal).

ILLUSTRATION.—Plate 88.

FLORISTICS.—

(i) *Naini Tal, U. P.* 2,250 m.—

I. *Cupressus torulosa** (a).

II. *Quercus dilatata* (a), *Q. incana* (f).

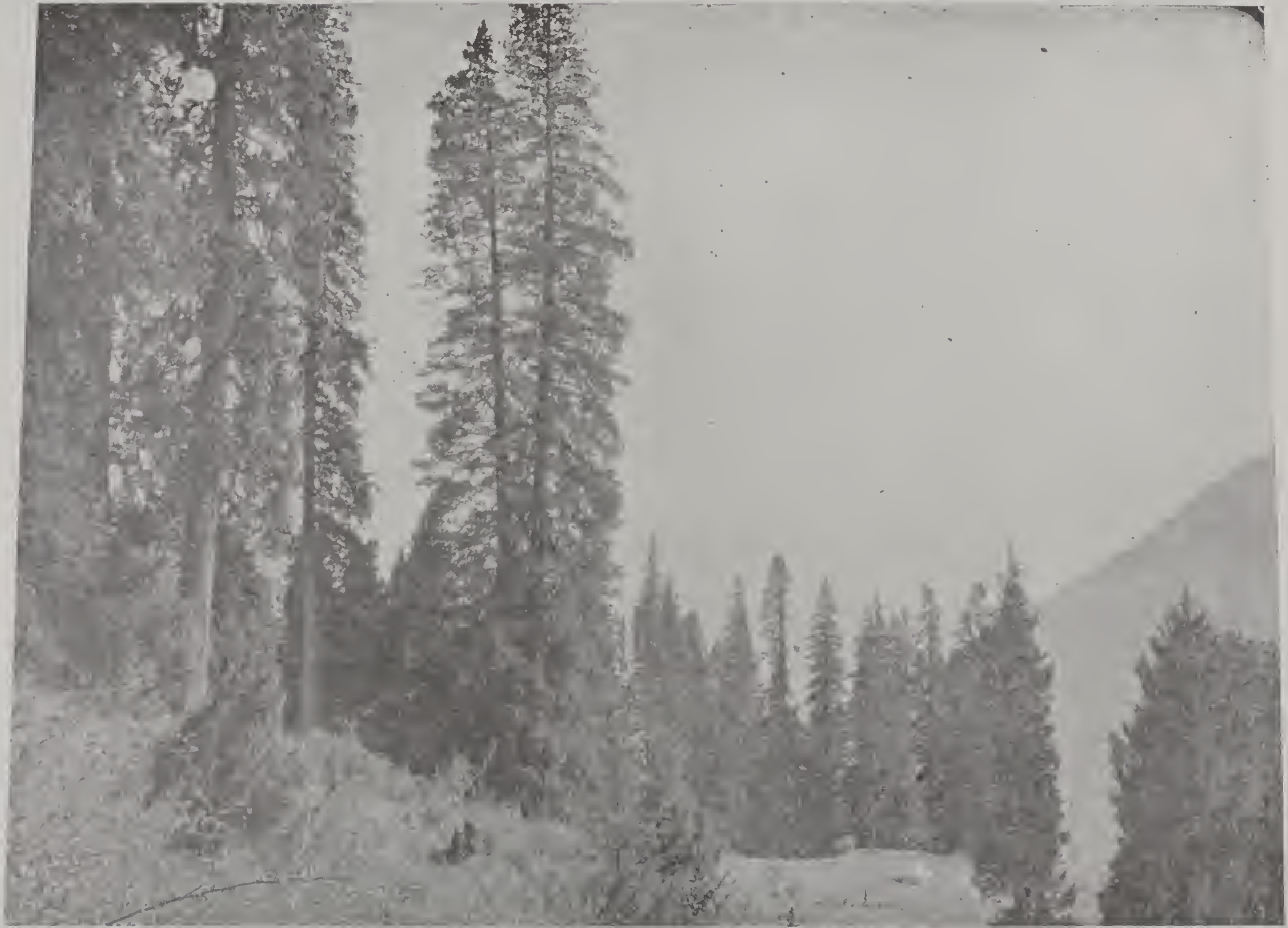
IIa. *Thamnocalamus falconeri* (lf).

III. *Abellia triflora.*

(ii) *Wan, Garhwal Division, U. P.* Preservation Plot No. 8 (1936), 2,600 m.—

I. *Cupressus torulosa**, *Cedrus deodara* (n).

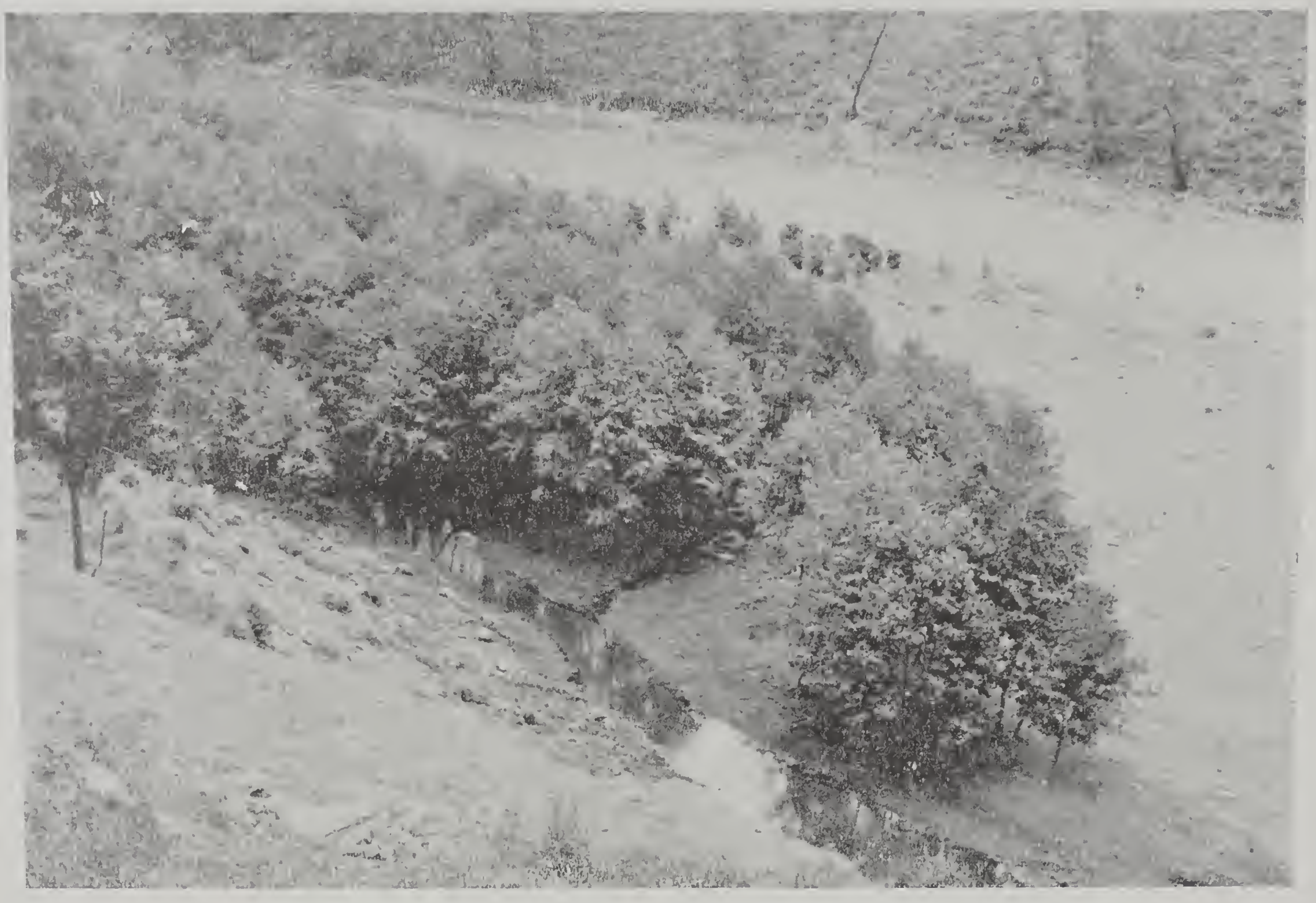
II. *Juglans* (o), *Pvrus pashia* (f).



CYPRESS FOREST

Magnificient grove of lofty trees (Temple grove). Wan, North Garhwal Division, Uttar Pradesh.

E. C. Mobbs



ALDER FOREST

Alnus nitida colony in an area closed for seven years. Beas river bed near Kulu, Kulu Division, Punjab.

S. K. Seth

III. *Cotoneaster bacillaris* (lf), *Prinsepia*, *Salix* sp., *Berberis* sp., *Rosa* sp.

NOTE.—This plot is an exceptional temple grove with trees upto 8.7 m. girth.

ECOLOGICAL STATUS.—BOR considers this a preclimax in the Aka Hills occurring on limestone, but believes that it once covered a much larger area than it does now, having lost ground from fires which *Pinus wallichiana* is better able to withstand. The nature of its occurrence certainly suggests that its presence is due primarily to soil conditions on which it is able to compete successfully with the other species and types of the moist temperate zone.

1S1. Alder forest

DESCRIPTION.—Typically nearly pure forest 20—30 m. high as a strip of varying width along stream sides, spreading out to larger areas on landslips and screes (OSMASTON reports upto 40 ha); more or less deciduous. An underwood may or may not be present, its amount and composition depending on site and conditions. In the lower courses of the streams where the fringe of alder is the only remaining tree growth owing to cultivation, there is often an under growth of inedible or thorny shrubs, whilst in the better wooded tracts progression starts early and other species, notably blue pine and other conifers, are usually present.

DISTRIBUTION.—Along the banks of the larger streams, sometimes extending up ravines and moist unstable hill sides along the whole Himalayan range, but absent from Kashmir.

LOCALITY FACTORS.—Limited to sites with permanent water supply. It occurs on newly formed shingle beds along the streams, and on landslips and screes where not too dry; also on river banks with the roots often exposed in the water, and in swampy ground. Mycorrhiza are known to occur on the roots. The altitudinal range is a wide one extending from the lower oak downwards into the subtropical belt to about 1,000 m. in the west, and upwards through the middle and upper oak to about 3,000 m. As would be expected the range also extends well into the dry temperate regions.

ILLUSTRATION.—Plate 89.

FLORISTICS.—

(i) *Beas Valley, Kulu, Punjab.*—

I. *Alnus nitida**, *Populus ciliata* (o), *Ulmus villosa* (a), *Celtis* sp. (o).

II. *Crataegus crenulata* (a), *Sarcococca* (la), *Spiraea.*

III. *Plectranthus* sp. (la), *Berberis* sp. (a), *Prinsepia* (f).

(ii) *Kumaon and Garhwal*—

I. *Alnus nepalensis**, *Populus ciliata.*

(iii) *Bengal.*—

I. *Alnus nepalensis**, *Trema orientalis.*

(iv) *N. E. F. A.*—

BOR (1938) described a *Populus—Alnus hulis* as occurring at 1,800 to 2,000 m., in steep valleys on hill wash in the Aka Hill, which appears to belong here. With the tow dominants occur *Fraxinus floribunda*, *Prunus nepalensis*, *Machilus edulis* and occasionally *Pinus wallichiana*.

1S2. Riverain blue pine forest

DESCRIPTION.—Irregular often dense stands of blue pine with occasional *Picea* and/or *Cedrus*, and sometimes *Populus* and *Alnus* with little or no undergrowth at first, but often becoming more open with inedible or thorny shrubs, if grazed.

DISTRIBUTION.—Throughout the coniferous belt from 1,700 to 3,000 m. on new alluvial deposite.

FLORISTICS.—

I. *Pinus wallichiana** (a), *Picea* (o), *Cedrus* (o), *Populus* (o), *Alnus* (o).
II. *Berberis* sp.

ILLUSTRATION.—Plate 90.

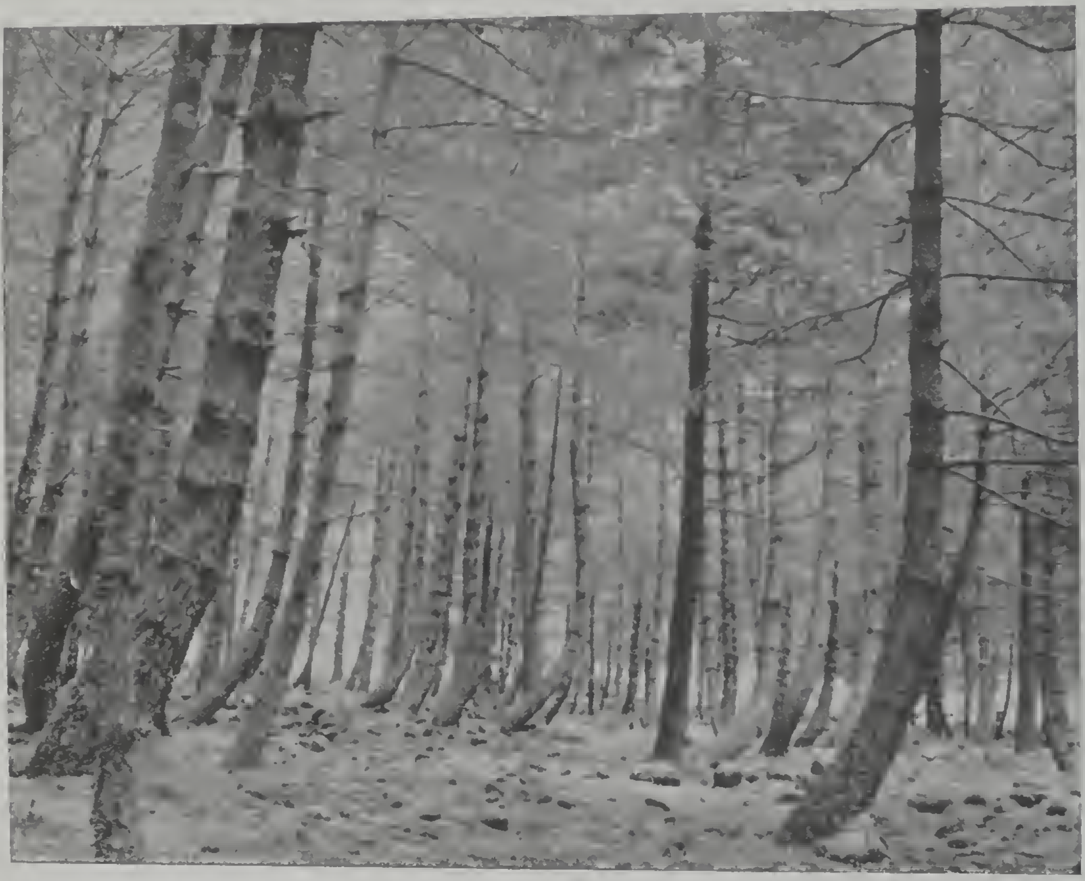
NOTE.—This type is found on shingle banks in or bordering the mountain streams wherever there is a source of seed. It may be eroded after a period or may gradually develop a soil and progress to the coniferous type appropriate to the altitude.

2S1. Low-level blue pine forest

DESCRIPTION.—These forests from the nature of their origin are typically more or less evenaged with blue pine pure or strongly predominating. Some deodar is often intermixed where a seed source has been present; similarly spruce on cool moist sites. They tend to be dense unless thinned out by fire, and to have very little undergrowth, the ground being covered with a layer of needles through which more or less grass and herbaceous growth comes up in the summer. On southern slopes, especially when the growth is open, there is a good deal of scrub growth of *Berberis*, *Indigofera*, etc., which persists in varying degree as the pine grows up and closes.

DISTRIBUTION.—The whole length of the Himalayas but in the east only locally in the inner ranges beyond the reach of heavy monsoon rainfall and similarly only behind the main axis in Kumaon, becoming more widespread in the Punjab and N. W. At all elevations from about 1,500 to 2,400 m.

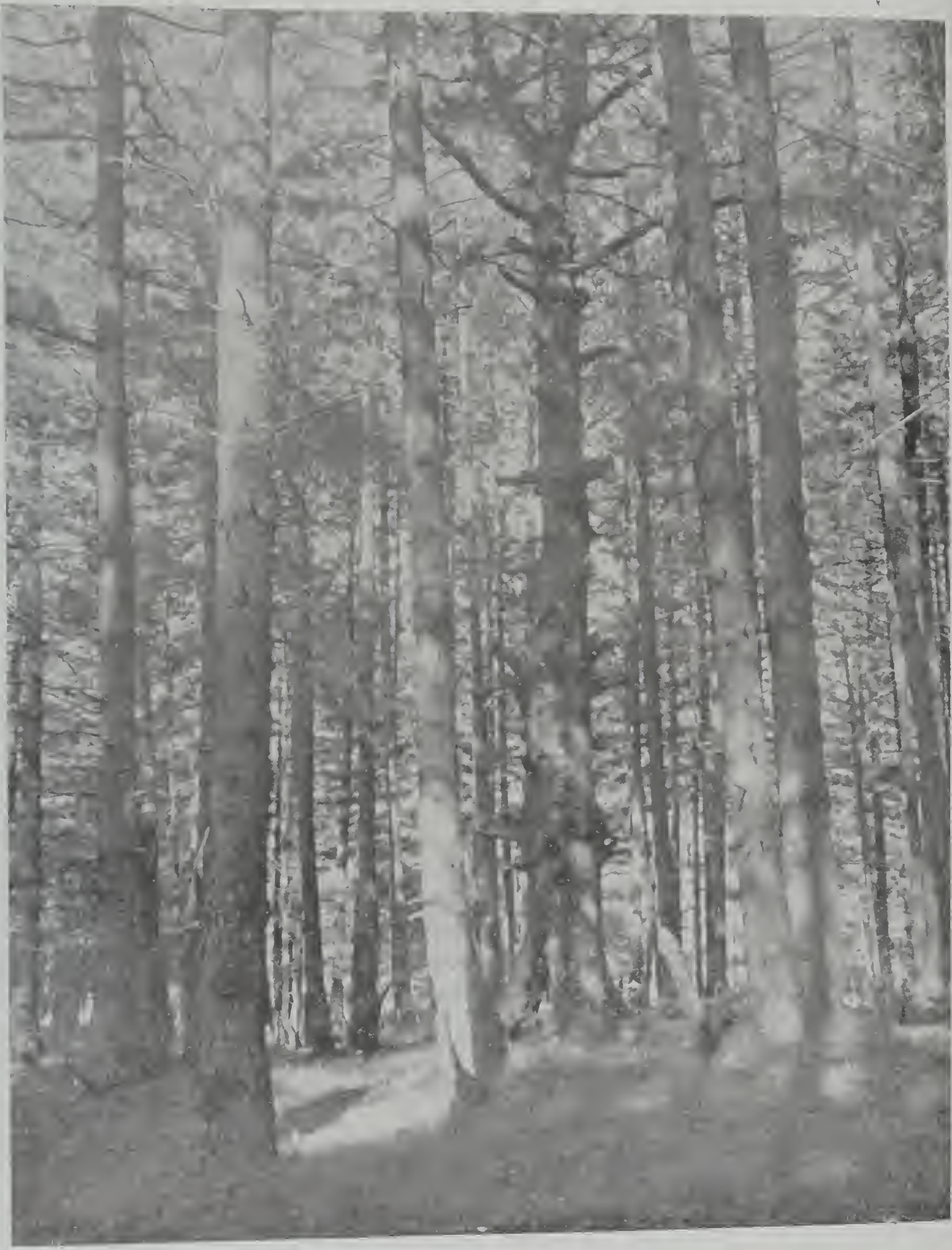
LOCALITY FACTORS.—The sites on which this type occurs are now usually at the lower edge of the (residual) forest on moderate slopes (even gentle on the Kashmir *Karewas*) adjoining or near to village cultivation. Very usually traces of former rough terracing indicate that the land has been cleared and at least partially cultivated in the past. On steeper ground there is similar evidence that a forest cover has been destroyed by fire, and/or grazing with associated lopping and fuel collection. Frequently, scattered large heavily branched old *kail* survive, being evidently the mother trees of the present crop. Most of these pure blue pine crops unquestionably owe their origin to the introduction of protection 50—70 years ago.



RIVERAIN BLUE PINE FOREST

Riverain *Pinus wallichiana* with few deodar. Babahar Babal Comptt. I, near Nagar, Kulu Division, Punjab.

H. G. Champion



LOW LEVEL BLUE PINE FOREST

Pinus wallichiana community, with lopped mother tree and progeny, on Karewa formation. Shopian, Jammu & Kashmir.

H. G. Chambion

ILLUSTRATION.—Plate 91.

FLORISTICS.—

(i) *Surd, Bashahr, H. P.*, 2,400 m. (after PURI).—

I. *Pinus wallichiana** (va), *Picea* (o).

II. None.

III. *Desmodium tiliaefolium* (a), *Indigofera gerardiana* (a), *Rosa macrophylla* (f), *Berberis* sp. (f), *Rubus niveus*, *Strobilanthes* sp. (f).

IVa. *Geranium* sp.(a), *Valeriana* sp. (a), *Viola* sp.(a), *Ainsliaea aptera*, (f), *Pteridium* (f), *Iris* (lf).

V. *Clematis* sp. (o), *Hedera* (o), *Rosa moschata*.

(ii) *Batote C* 11, *Jammu*, 1,800 m. —

I. *Pinus wallichiana**.

II. *Quercus dilatata* (o), *Q. incana* (o).

III. *Viburnum* sp. (va), *Sarcococca* (va), *Wikstroemia* (a), *Myrsine* (la).

IVa. *Adiantum, Fragaria.*

V. *Rosa moschata.*

(iii) *Aka Hills, NEFA.*—

BOR (1933) describes the occurrence of blue pine associations between 1,600 and 2,800 m. on deep moist soils at the foot of slopes but they also grow well on dry soils. From the context they appear to be seral in status.

ILLUSTRATION.—BOR, Plate 12.

GROUP 13. HIMALAYAN DRY TEMPERATE FORESTS

1. NOMENCLATURE

Jammu & Kashmir	Dry zone deodar forests (Working Plans).
Punjab and Himachal Pradesh	Dry zone and Arid zone formations, including VIII, *Ilex-neoza* pine; IX, Dry zone deodar; XI, Arid zone *neoza* and XII Arid zone deodar (GORRIE).
Uttar Pradesh	*Pinus-Cedrus* formation (drier parts only) (OSMASTON).

2. GENERAL DESCRIPTION

Essentially an open formation with locally closed canopy only on favourable sites perhaps indicating postclimax conditions. Conifers predominate, such broadleaved trees as occur being of poorer height growth and occurring either scattered among the conifers or forming more or less pure patches. Xerophytic shrubs occur freely and may form a continuous cover but more often leave a good deal of the soil exposed. Epiphytes and climbers hardly occur.

3. DISTRIBUTION

The inner ranges of the Himalayas where the S. W. summer monsoon is but feebly felt and the precipitation, which is usually under 1,000 mm., falls mainly as snow in the winter months; Kashmir (Ladakh), Lahaul, Chamba, Bashahr, inner Garhwal, Sikkim and probably N. E. F. A.

4. LOCALITY FACTORS

The altitudinal range is from about 1,700 m. upwards. Subtropical vegetation penetrates a long way up the deep valleys of the biggest rivers into the dry zones.

Temperature (centigrade)

Himalayan Dry Temperate Forests

Month	Kashmir GILGIT 1,491 m.			Kashmir LEH 3,514 m.		
	Mean	Mean maximum	Mean minimum	Mean	Mean maximum	Mean minimum
January	4·0	7·9	0·0	—7·0	—1·4	—13·3
February	7·1	11·4	2·7	—5·7	0·6	—12·1
March	12·1	16·9	7·3	0·4	6·9	—6·1
April	16·9	22·3	11·5	6·1	13·0	—0·9
May	21·6	27·9	15·2	10·2	17·6	2·8
June	26·0	32·9	19·1	14·3	21·8	6·8
July	28·7	35·3	22·1	17·4	24·7	10·2
August	27·9	34·2	21·7	17·1	24·4	9·8
September	23·4	29·5	17·2	13·2	20·9	5·4
October	17·2	23·2	11·2	6·9	14·6	—0·7
November	11·0	16·8	5·2	0·9	8·2	—6·4
December	5·5	9·9	1·0	—4·4	1·8	—10·7
M. A. T.	16·8	..	..	5·8	..	..
Annual mean maximum	22·4	..	..	12·8	..	..
Highest record	44·4	..	..	33·9	..	..
Annual mean minimum	11·2	..	..	—1·3	..	..
Lowest record	—6·1	..	..	—28·3	..	..
No. of years	45	..	..	60	..	..

GORRIE (1933) has collected some approximate data for soil temperatures in U. Bashahr at 2,150 m. and 2,750 m. They indicate summer maximum at the surface of about 54·4° C. and 51·7° C. respectively and of 22° C. lower (and so about 32·2°) at a depth of 50 mm., the corresponding minima being a little over 16° C.

Precipitation.—Snowfall is important in this type of forest as it helps to maintain the moisture supplies during the summer months when there is little rainfall. The snow line is highest in July and August, and the forest belt is mostly clear of snow early in May though drifts and snow bridges last till August. GORRIE gives some rough figures for the cumulative depth, *viz.*, 2·1 m. at 1,800 m., 4·3 m. at 2,440 m. and 5·5 m. at 3,050 m., in the Chini-Kailas sector with about 60 mm. total precipitation (as water).

Temperature.—Of the rainfall stations referred to above, temperature data are only available for Gilgit and Leh, the latter being at subalpine altitudes.

Rainfall (millimetres)

Himalayan Dry Temperate Forests

Month	Kashmir GILGIT 1,491 m.	Himachal Pradesh PU 3,050 m.	Himachal Pradesh KILBA 1,890 m.	Kashmir LEH 3,514 m.
January	6	53	81	10
February	7	53	87	8
March	20	81	118	7
April	24	56	93	6
May	20	23	62	6
June	9	8	40	5
July	10	15	83	12
August	14	15	72	15
September	10	13	80	7
October	6	13	23	3
November	1	8	23	1
December	3	18	35	5
Total for year M. A. R.	132	356	798	83
No. of rainy days	15	?	62	11
No. of months with less than 50 mm.	12	8	4	12
M. A. Humidity	49	?	?	55
No. of years	45	?	59	60

Soil and Topography.—The type is confined to hilly country which is generally similar to that occupied by the moist temperate forests, and most of it is on steep, often rocky slopes. All main rock types are represented; screes, landslips and similar features are of frequent occurrence.

Biotic factors.—Fire is relatively uncommon as from the open nature of the cover fire does not easily spread, but serious damage is liable to occur in the dry summer months in the better stocked areas. Grazing is very prevalent and has a marked effect on the vegetation.

5. GENERAL FLORISTICS

Conifers predominate, *Cedrus deodara*, *Pinus gerardiana* and *Juniperus* being most characteristic, with *Abies* and *Pinus wallichiana* at higher elevations. Among the broadleaved trees, characteristic xerophytic species of the moist zone genera occur such as *Acer*, *Fraxinus* and *Quercus*. The shrubs are similarly largely of the same genera as in the moist zone but *Artemisia*, *Astragalus* and *Ephedra* are most typical. GORRIE (1933) gives detailed lists of associated plants in the Sutlej Valley, whilst MOHAN (1955) has listed the typical grasses.

6. SUBDIVISIONS

Seven climax types will be described separately, *viz.*,

(i) Western types

C1. Dry broadleaved and coniferous forest (*Quercus ilex-P. gerardiana*).

C2. Dry temperate coniferous forest.

2a. Neoza pine forest (*P. gerardiana*).

2b. Dry deodar forest (*Cedrus*)

DS1. Pohu scrub.

DS2. Dry temperate scrub.

C3. (*West Himalayan dry temperate deciduous forest*).

C4. West Himalayan high-level dry blue pine forest (*P. wallichiana*).

C5. West Himalayan dry Juniper forest (*J. macropoda*).

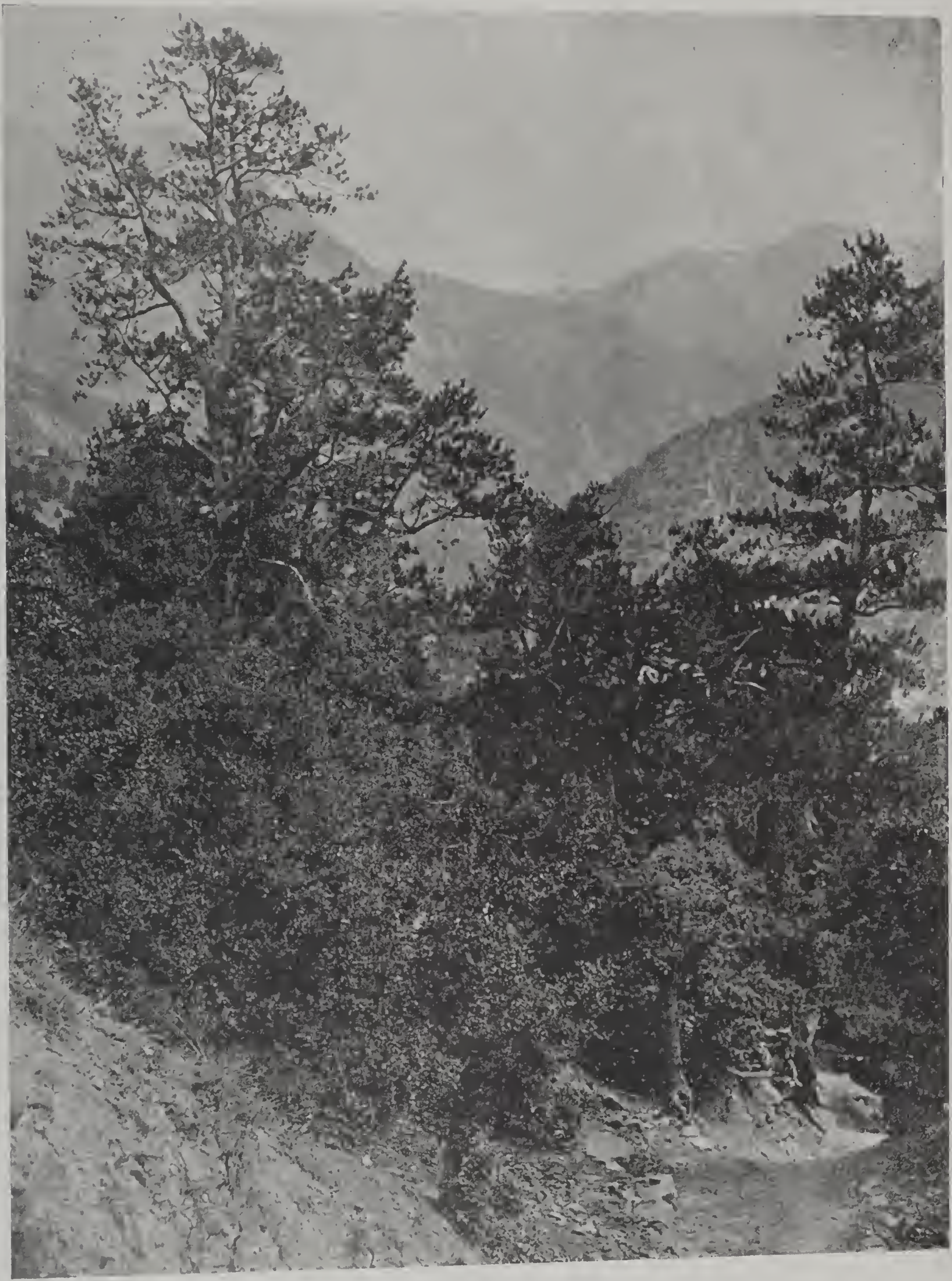
(ii) Eastern types

C6. East Himalayan dry temperate coniferous forest.

E1. Larch forest (*L. griffithiana*)

C7. East Himalayan dry Juniper/birch forest (*J. wallichiana*).

NOTE.—Evergreen oak and its broadleaved tree associates are confined to the lower elevations. As one goes up the valleys, the rainfall decreases and elevation increases, and the oak is restricted to the cooler and moister sites; the pine dominates on the hotter



DRY BROADLEAVED AND CONIFEROUS FOREST

Pinus gerardiana with *Quercus ilex* understorey. Poari Jhula, Chini, Upper Bashahr Division, Himachal Pradesh.

H. G. Champion

slopes even to 3,000 m., with deodar in place of oak. The blue pine with varying amounts of silver fir forms the upper belt of forest above the deodar. GORRIE (1933) differentiates "Dry" and "Arid" zones for the Sutlej Valley as may be advisable for forest management but it has been thought preferable to unite them here.

C1. Dry broadleaved and coniferous forest (Quercus ilex-P. gerardiana)

NOMENCLATURE.—

General . . . Steppe forest (*Q. ilex*) (SCHWEINFURTH).

DESCRIPTION.—An open forest of pine rarely exceeding 16 m. in height mixed with evergreen oaks and a few other xerophytic trees which together may form a fairly complete cover at least on sheltered sites and cool aspects, but generally leave much of the soil exposed. There is a fair amount of low shrub growth, definitely xerophytic and often aromatic, and thin grass. Locally the pine is absent and oak predominates.

DISTRIBUTION.—The inner dry Himalayan valleys from 1,600 m. upwards notably in the Upper Sutlej and Kishtwar valleys.

LOCALITY FACTORS.—The type occurs between 2,000 m. and 2,440 m. extending 300 m. lower, on cool aspects and 300 m. higher on southerly exposures. The rainfall varies from about 660 mm. to 900 mm., Kilba being fairly representative.

ILLUSTRATION.—Plate 92.

FLORISTICS.—

(i) *Kilba,, U. Bashahr Division, Punjab* (After GORRIE)—

I. *Pinus gerardiana** (a), *Cedrus deodara* (o), *Quercus ilex** (a), *Acer pentapomicum* (o) *Celtis australis* (r).

II. *Fraxinus xanthoxyloides* (o), *Rhus succedanea* (o), *Parrotia jacquemontiana* (lf), *Olea cuspidata* (lf), *Zanthoxylum alatum* (o).

III. *Artemisia maritima* (a), *A. vulgaris* (a), *Daphne oleoides* (lf), *Plectranthus rugosus* (f), *Rosa webbiana* (f), *Berberis* spp. (f), *Roylea calycina* (lf), *Lonicera angustifolia* (lo), *Sophora mollis* (la), *Abelia triflora*.

IVb. *Agropyron longearistatum*, *Agrostis alba*, *Eragrostis nigra*, *Perotis indica*, *Phleum arenarium*, *Setaria viridis*.

V. No climbers.

C2. Dry temperate coniferous forest

C2a. Neoza pine forest (P. gerardiana)

NOMENCLATURE—Steppe forest (*P. gerardiana*) (SCHWEINFURTH).

DESCRIPTION.—Open nearly pure pine crops, locally with some deodar. An equally open shrub growth occurs among the pine but a great deal of the surface is bare. The forests are much frequented for the collection of the pine seed.

DISTRIBUTION.—Inner dry valleys of the West Himalayas including the Kishtwar valley but not Kashmir.

LOCALITY FACTORS.—Mainly in the arid zone with rainfall less than 500 mm., falling mainly in February to April. The forests are mostly on steep slopes and north exposures.

ILLUSTRATION.—Plate 93.

FLORISTICS.—

Purbani, U. Bashahr, Punjab, about 500 m n. (rainfall 2,600 mm) —

I. *Pinus gerardiana** (a), *Cedrus deodara* (o)

II. *Fraxinus xanthoxyloides* (o).

III. *Lonicera hypoleuca*, *Artemisia maritima*, *Daphne oleoides*, *Ephedra gerardiana*, *Caragana gerardiana*, *Prunus jacquemontii*.

NOTE.—This is GORRIE's (1933) arid zone *neoza* pine forest. He gives fuller lists of associated species, *loc. cit.*, p. 48.

JHUNNA SINGH (1937) has provided a useful commentary and supplement to GORRIE's publication with special reference to the altitudinal ranges of types and species in their relation to aspect.

C2b. Dry deodar forest

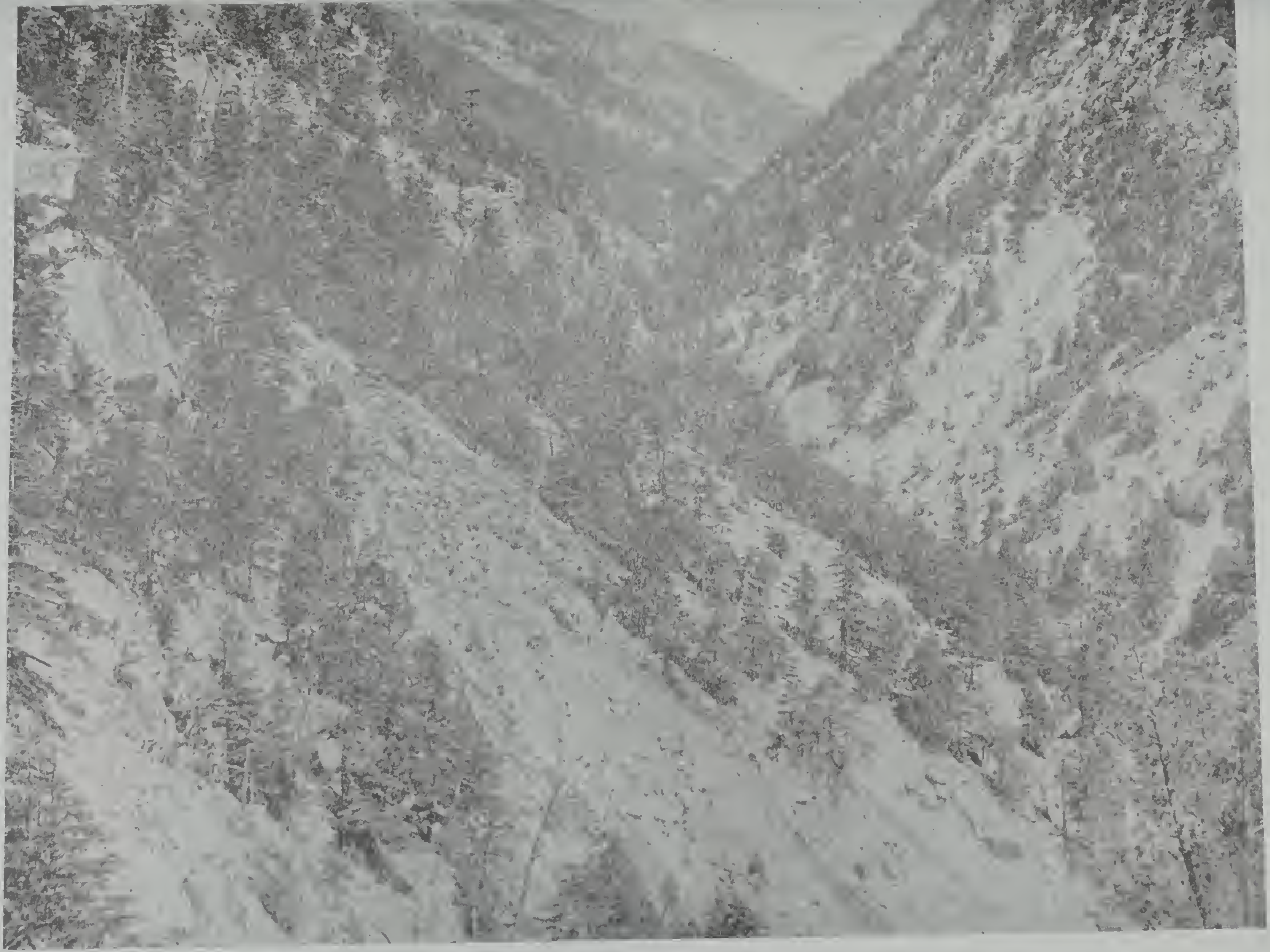
DESCRIPTION.—A nearly pure coniferous forest, broadleaved trees being confined to the moister ravines, etc., and to transitions to the foregoing type. It varies from the complete canopy formed by the better patches of deodar to a very open crop of low branching trees in the more arid parts, and the height varies correspondingly from 20 m. or more down to 14 m. The deodar tends to be gregarious and to form nearly pure crops on the moister aspects with *Pinus gerardiana* on the drier, but open mixed crops are common especially in the more arid tracts where the pine extends much higher up the slopes (even over 3,000 m.) than it does with a higher rainfall. Blue pine is frequently present and may also occur pure over limited areas, especially at the higher elevations. Its status is uncertain cf. p. 328 and p. 330.

There is usually a good deal of shrubby undergrowth including many species common in the moist deodar type. In the drier and more open forests, the shrubs are more markedly xerophytic and similar to those of the *Quercus/P. gerardiana* type.

DISTRIBUTION.—Inner dry valleys of the W. Himalaya, especially the Upper Sutlej and Chenab (Kishtwar).

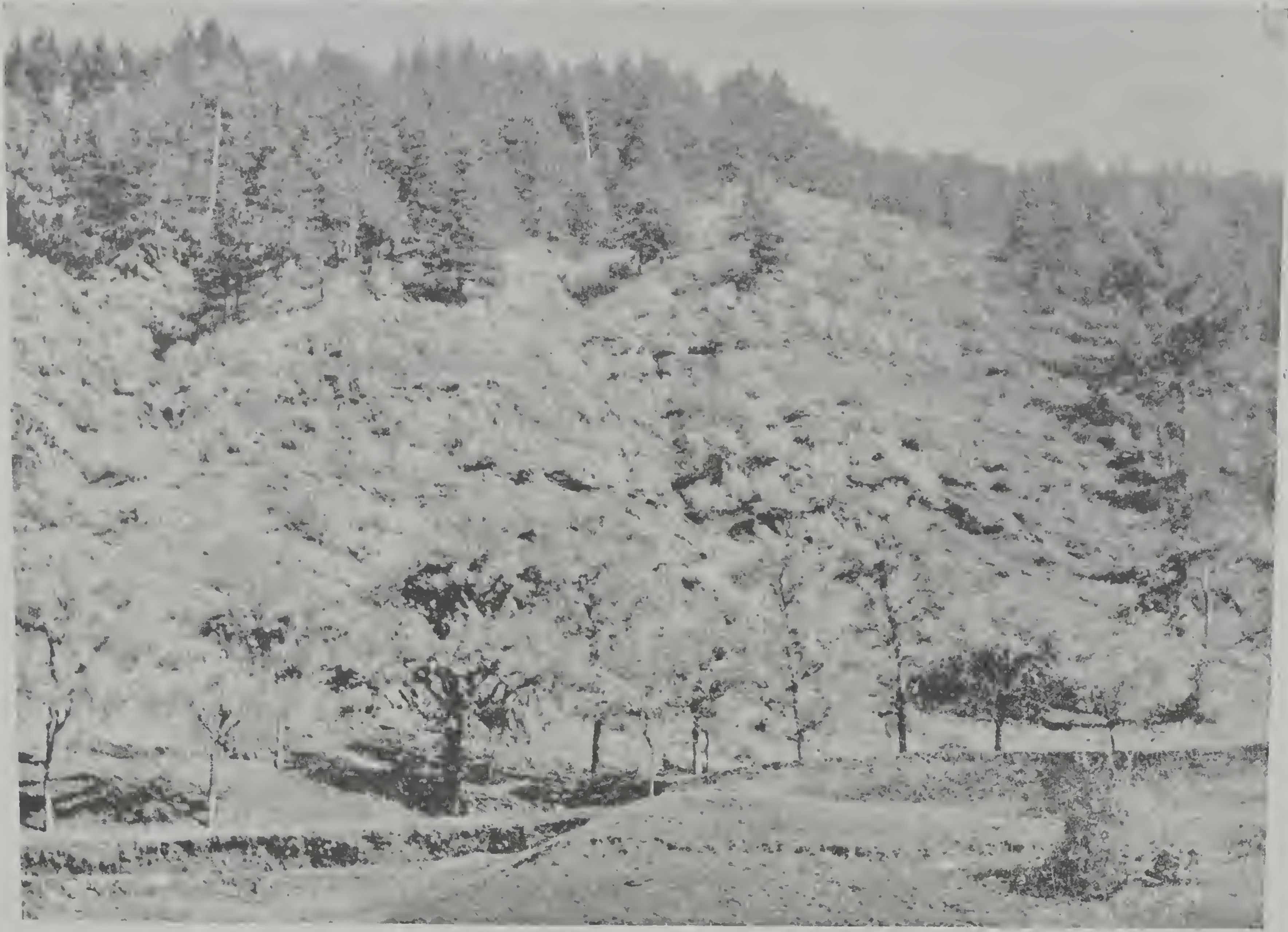
LOCALITY FACTORS.—This type is met with from elevations of about 2,100 m. up to the alpine forests at about 3,250 m. The rainfall rarely exceeds 1,000 mm. and may be as low as 500 mm. or even less. The summer is dry and much of the precipitation is in the form of snow, the gradual melting of which helps to check the drying out of the soil. The figures for Kilba and Pu may be seen on p. 323.

ILLUSTRATION.—Plate 93.



DRY TEMPERATE CONIFEROUS FOREST
Open crop of *Cedrus deodara* (75%) and *Pinus gerardiana* with open tufted shrubs between Pangi,
Upper Bashahr Division, Himachal Pradesh.

H. G. Champion



POHU SCRUB

Parrotia Jacquemontiana scrub in deodar forest, on an overgrazed hill slope. Jammu & Kashmir. *G. S. Mathauda*

7 FRI& C/64

FLORISTICS.—

(i) *Kilba, U. Bashahr Division, Punjab* (813 mm. rainfall; altitude 2,440 m.; from 4 Sample Plots).

I. *Cedrus deodara** (va), *Pinus wallichiana* (o), *Picea smithiana* (o).

II. *Corylus colurna* (o).

III. *Viburnum cotinifolium* (f), *Desmodium tiliaefolium*(o), *Lonicera quinquelocularis* (o), *Smilax vaginata* (o), *Rubus niveus* (f), *Berberis* sp. (f), *Plectranthus rugosus* (f).

IVa. *Fragaria vesca* (f), *Viola canescens* (o), *V. patrinii* (o), *Thalictrum minus* (f), *Salvia glutinosa* (f), *Impatiens* spp. (f).

NOTE.—These forests are on a northern aspect and represent the moist end of the range, approximating to the moist coniferous type and belonging to GORRIE's "dry zone deodar".

(ii) *Chini, U. Bashahr Division, Punjab* (about 635 mm. rainfall, altitude 2,440 m).

I. *Cedrus deodara** (a), *Pinus gerardiana* (f).

II. Nil.

IVa. *Artemisia maritima, Lonicera hypoleuca, Microglossa, Ribes grossularia, Rosa webbiana, Abelia triflora.*

NOTE.—This is GORRIE's Arid Zone deodar. He gives fuller lists of associated vegetation, *loc. cit.* p. 60.

C2/DS1. Pohu scrub

In some parts of the dry deodar zone where the shrub *Parrotia* is abundant, felling of the deodar is liable to leave the *Parrotia* in full possession of the ground, sometimes over quite extensive areas, notably in Kashmir.

ILLUSTRATION.—Plate 94.

C2/DS2. Dry temperate scrub

Clearing of the forest followed by grazing and sometimes fire also, results in the development, with continued grazing mostly by sheep and goats, of low open scrub cover in which the less palatable species predominate, *e.g.*, *Plectranthus rugosus*, *Berberis* spp., *Rosa* spp. SCHWEINFURTH's Kashmir scrub would be included here. The type appears to be more xerophytic than the last.

C3. (West Himalayan dry temperate deciduous forest)

The temperate deciduous forest extends well into the dry zone behind the Himalayan axis, with rainfall under 1,000 mm. and should perhaps be viewed as a *postclimax* on moist soils. Development is naturally not so good but appearance and composition is not very different. OSMASTON mentions pure woods 15—18 m. high of *Corylus colurna* upto 60 ha in extent on cool northerly aspects between 2,400 m. and 2,750 m. in North Garhwal and similar forests occur in Kashmir and Himachal Pradesh. Such development may suggest soil water supply above average for the zone,

C4. West Himalayan high level dry blue pine forest (P. wallichiana)

DESCRIPTION.—Very open forest often heavily infested by *Arceuthobium.*

DISTRIBUTION.—The arid zone of the inner Western Himalaya at high elevations of 3,000 m. to 3,600 m., *e.g.* Ladakh and Kanawar.

LOCALITY FACTORS.—With rainfall below 500 mm., the forest is to a large extent dependent on the slow melting snow beds on the gentle slopes of the colder northern aspects.

ILLUSTRATION.—OSMASTON (1922), Plate X.

FLORISTICS.—(After GORRIE).

I. *Pinus wallichiana**, *P. gerardiana*, *Abies spectabilis.*

II. *Betula utilis*, *Sorbus foliolosa*, *Rhododendron campanulatum.*

III. *Juniperus communis*, *J. wallichiana*, *J. macropoda*, *Rhododendron anthopogon*, *Salix* spp., *Caragana* sp., *Ephedra*, *Lonicera* spp.

NOTE.—GORRIE has been followed in according this type climax status though it merges into the moister High Level Blue pine sub-alpine forest.

C5. West Himalayan dry juniper forest (J. macropoda)

NOMENCLATURE.—Steppe forest (*Juniperus* spp.) (SCHWEINFURTH).

DESCRIPTION.—An open evergreen forest of low height with a varying amount of dry evergreen undergrowth.

DISTRIBUTION.—The innermost arid zone of the Western Himalayas from Ladakh (Kashmir) and Lahaul (Punjab) to Garhwal (U. P.) at 2,500 to 4,300 m.

LOCALITY FACTORS.—Rainfall probably under 300 mm. with very low winter temperatures.

ILLUSTRATION.—Plate 95.

FLORISTICS.—(OSMASTON).

(ii) *Niti, Alaknanda Valley, Garhwal, Uttar Pradesh.* —

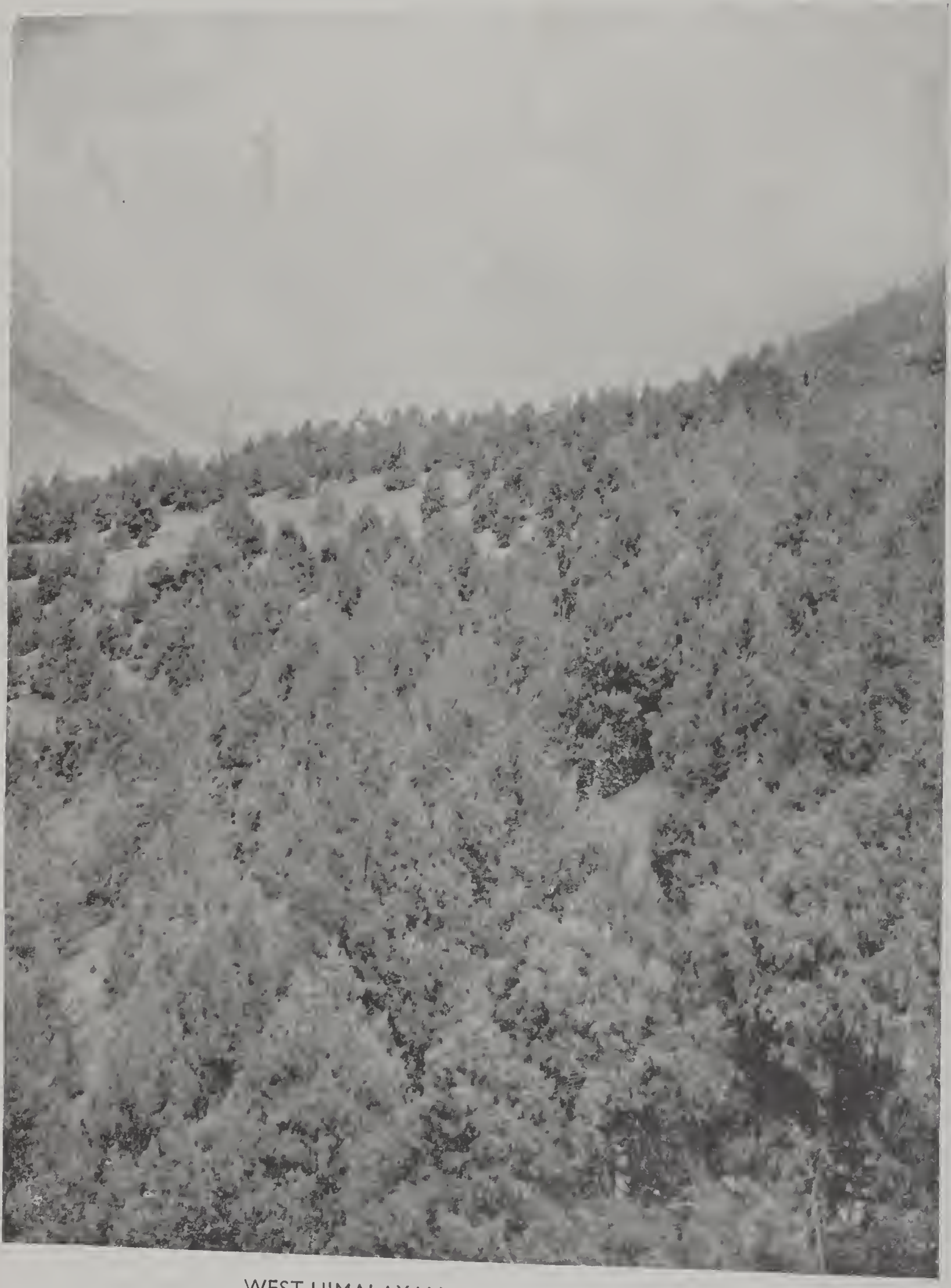
I. *Juniperus macropoda** (5—8 m. high).

II. *Fraxinus xanthoxyloides*, *Rosa webbiana*, *R. sericea*, *Ribes grossularia.*

C6. East Himalayan dry temperate coniferous forest

NOMENCLATURE.—Temperate coniferous forest of continental valleys (SCHWEINFURTH).

DESCRIPTION.—No good description is available but the type is apparently a mixed coniferous forest of hemlock and spruce with varying amounts of blue pine, sliver fir and juniper. There is an underwood of *Rhododendron* spp. (NOT SEEN).



WEST HIMALAYAN DRY JUNIPER FOREST

Juniperus macropoda forest near Kyelang, Lahul, Punjab.

N. L. Bor

the *J. macropoda* of the inner western mountains, and occurs between 2,800 and 4,500 m. *J. wallichiana* occurs equally in the Western Himalaya but does not reach tree dimensions there.

GENERAL SERAL TYPES OF DRY TEMPERATE FORESTS

1*S*1. *Hippophae/Myricaria* brakes.

1*S*2. *Populus/Salix* forest.

1*S*3. (Western high-level dry blue pine forest).

1S1. Hippophae—Myricaria scrub

DESCRIPTION.—A more or less pure thicket of *Hippophae salicifolia*, 3—6 m. high, with some admixture or undergrowth of *Salix* spp., *Myricaria* spp., and occasional *Populus ciliata* at the lower elevations, and tufts of grass and herbs such as *Thymus serpyllum.*

DISTRIBUTION.—On gravel along inner Himalayan streams from 2,300 m. (sometimes down to 1,500 m.) up to about 3,200 m.

ILLUSTRATION.—Plate 96.

FLORISTICS.—

(i) *Sunderdhunga Valley, Kumaon, Uttar Pradesh,* 2900 m.—

I. *Hippophae salicifolia** (va), *Salix elegans* (o).
II. *Thymus serpyllum* (la), *Epilobium* sp. (f).

NOTE.—The *Salix* was evidently the later arrival and *Hippophae* appeared to die out on the older levels, leaving the *Salix* predominating and *Berberus, Juniperus,* etc. slowly coming in.

(ii) *Baspa Valley, Himachal Pradesh.*—

I. & II. *Hippophae salicifolia** (a), *Salix viminalis* (a) *Myricaria elegans**, *M. germanica.*

NOTE.—This type extends upto the Sub-alpine zone.

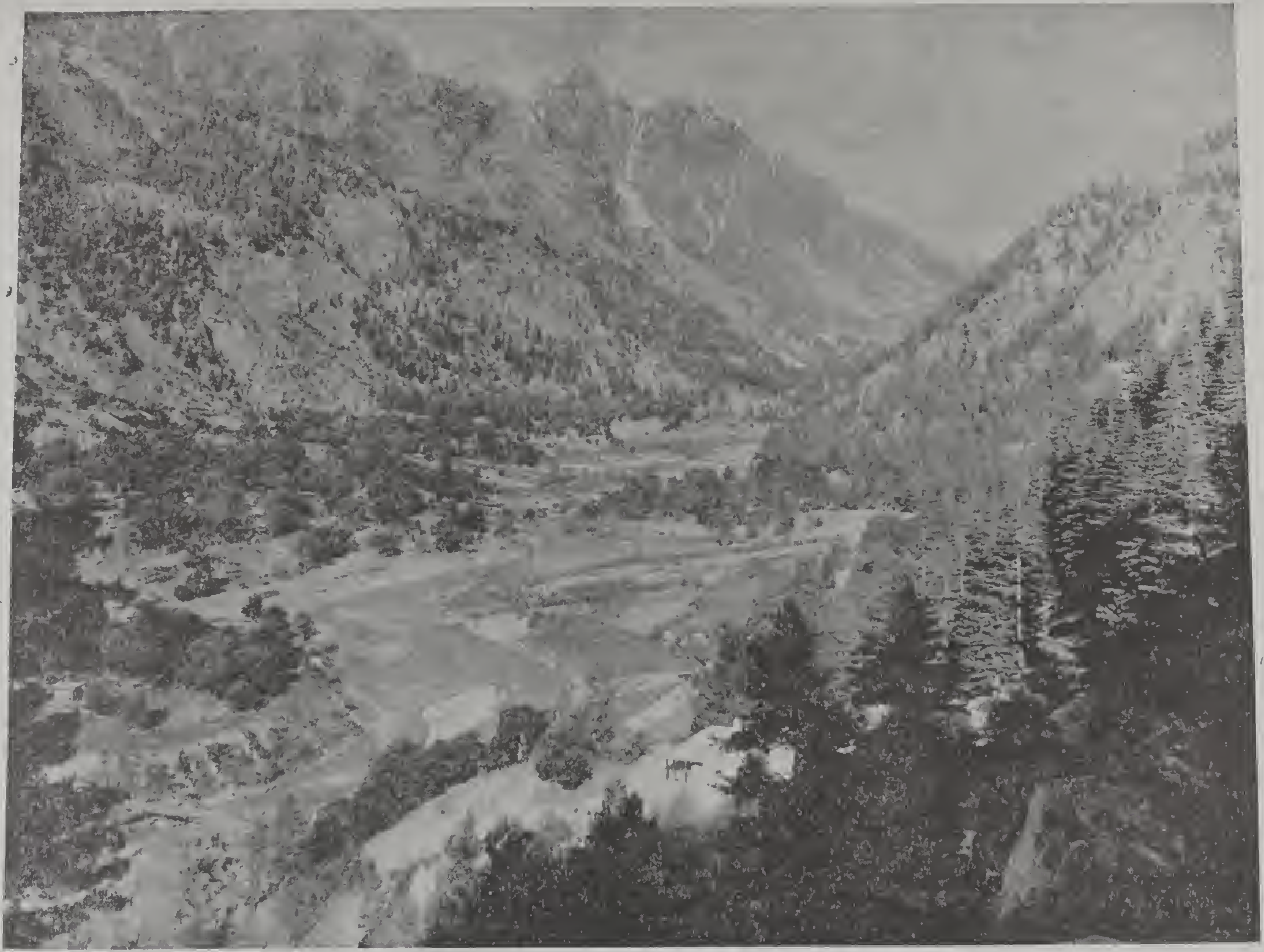
GENERAL NOTE.—In the inner vallyes, *Hippophae* replaces the alder of the outer hills as the colonist of new gravel deposits, earth slides, etc. Like alder it often appears to be a stable formation owing to the maintenance of conditions by erosion and new deposition, but is usually clearly seral and may be followed by poplar (OSMASTON) and ultimately by the local coniferous or broadleaved climax.

1S2. Populus—Salix forest

Communities of *Populus euphratica* are found in the upper Indus valley (Ladakh) at 3,000 to 4,000 m., apparently associated with *Salix* spp., but no further description is available.

1S3. (Western high-level dry blue pine forest)

Climax status is accorded to some at least of the high level blue pine, *vide* C4 on page 328 but it is still the pioneer on any bare soil.



HIPPOPHAE-MYRICARIA SCRUB

Hippophae-Salix association on valley bottom, *Juglans regia* on lower deposits, *Cedrus deodara* above Sangla, Upper Bashahr Division, Himachal Pradesh.

M. V. Laurie

CHAPTER X

SUB-ALPINE FORESTS

GROUP 14. SUB-ALPINE FORESTS

1. NOMENCLATURE

General	Subalpine forest (*Betula*) (SCHWEINFURTH).
Jammu and Kashmir	Subalpine Zone (SHER SINGH).
Punjab and Himachal Pradesh	(1) *Kharsu* oak—Silver fir belt (top part). (2) Dry zone silver fir—blue pine-formation. (3) Arid zone blue pine formation (GORRIE).
Uttar Pradesh	*Betula-Abies* and *Rhododendron-Lonicera* associations of a *Betula-Rhododendron* formation (OSMASTON).
Bengal	*Rhododendron* and Silver fir forest. *Rhododendron* forest.
Assam and N.E.F.A.	*Rhododendron* forest.
Manipur	*Rhododendron-Betula hylium* (DEB).

2. GENERAL DESCRIPTION

Typically dense growth of small crooked trees or large shrubs with patches of coniferous overwood. The conifer is very generally an *Abies*, characterised by a low-branching dense habit, and the blue pine which may occur with it likewise differs from the low level form in its shorter and denser foliage. The birch which is very typically present is the only broadleaved tree to develop a fairly clean tall bole, the rest having crooked branchy stems, which are usually bent at the base as a result of snow pressure. The forest is mainly evergreen as, although most of the other broadleaved species are deciduous, *Rhododendron* is by far the commonest constituent; the *Rhododendrons* may however lose much of their foliage from hail, etc., during the winter. Pure *Rhododendron* forest 3 to 10 m. high covers large areas in Sikkim and the N. E., with a few deciduous trees but no fir. Though many of the species tend to form consociations each at its own elevation and site conditions, mixtures are frequent and a dozen or more species may be found together. The amount of undergrowth is very variable from practically *nil* under the heavier *Rhododendron* thickets to a fairly complete if thin cover of mainly deciduous species under a higher canopy of birch, *Rhododendron* etc. There is a spring flush of flowers among which *Primula* spp., *Ranunculaceae* and *Compositeae* are generally conspicuous with *Meconopsis* (chiefly in the east); ferns are also often abundant. There is an appreciable amount of epiphytic moss and lichen, but otherwise epiphytes and climbers are rare.

The conifers rarely reach 30 m. except in sheltered spots and the broadleaved woods are usually about 6 to 10 m. high.

3. DISTRIBUTION

The topmost tree forest in the Himalaya adjoining Alpine scrub or grassland, often as strips along spurs between snow-slides, on sheltered slopes and other favourable spots, from Kashmir to the eastern parts of N. E. F. A. where it appears to be most extensively developed. It extends some way into the dry zone of N. W. India, but not into W. Tibet.

4. LOCALITY FACTORS

The altitudinal limits are about 2,900 m. and 3,500 m. as a rule but may extend 300 m. up—even higher in the West Himalayas, Ladakh or less commonly downward.

Temperature.—No temperature data for typical stations are available but those for Dras and Leh are given below. A severe winter is experienced with nightly temperatures well below zero for several months.

Temperature Data (centigrade)

Sub-alpine Forests

Month	Kashmir DRAS 3,066 m.			Kashmir LEH 3,514 m.		
	Mean	Mean max.	Mean min.	Mean	Mean max.	Mean min.
January	—15·7	—8·1	—22·3	—7·4	—1·4	—13·3
February	—14·6	—6·3	—22·8	—5·7	0·6	—12·1
March	—8·6	—1·3	—15·9	0·4	6·9	—6·1
April	—0·4	5·2	—6·2	6·1	13·0	—0·9
May	8·4	14·4	2·3	10·2	17·6	2·8
June	13·7	21·3	6·0	14·3	21·8	6·8
July	16·9	24·3	9·6	17·4	24·7	10·2
August	17·2	24·4	9·9	17·1	24·4	9·8
September	12·8	20·1	5·1	13·2	20·9	5·4
October	5·6	13·1	—1·8	6·9	14·6	—0·7
November	—2·7	4·4	—9·9	0·9	8·2	—6·4
December	—9·1	—3·7	—14·6	—4·4	1·8	—10·7
M. A. T.	2·0	..	..	5·8	..	..
Annual mean max.	9·0	..	..	12·8	..	..
Highest record	33·9	..	..	33·9	..	..
Annual mean min.	—5·4	..	..	—1·3	..	..
Lowest record	—45·0	..	..	—28·3	..	..
No. of years	45	..	..	60	..	..

Snow is a regular feature and may drift over the forest to a depth of 3 m. or more. GORRIE (1933) estimated the cumulative depth at 10,000 m. as 6 m. Snow slides are of frequent occurrence, often following regular paths on which forest cannot develop. The avalanches may cause avalanche winds very destructive to tree growth.

Precipitation regime.—No systematic records are available for typical sites in the zone but those for Dras and Leh in Ladakh are indicative though Leh is in the arid zone. From the fact that it is necessary to go well into the Himalaya to find extensive tracts at suitable elevations, heavy monsoon rainfall is not usually experienced, but in any case the forest is probably usually more dependent on melting snow for its water supplies than on rainfall during the short vegetative season and so is able to exist where the annual precipitation is very low but falls in the winter months as snow. The equivalent of 80 mm. rainfall may be estimated as the minimum necessary for its development. The figures given on pp. 323, 293 for the dry and moist temperate forests are indicative of conditions in the drier and moister tracts respectively, those for Kalimpong represent the rather different rainfall distribution of the E. Himalayas.

Rainfall (millimetres)

Sub-alpine Forests

Month	Kashmir DRAS 3,066 m.	Kashmir LEH 3,514 m.
January	97	10
February	97	8
March	138	7
April	104	6
May	61	6
June	17	5
July	16	12
August	14	15
September	18	7
October	20	3
November	12	1
December	54	5
Total for year (M. A. R.)	649	83
No. of rainy days	57	11
No. of months with less than 50 mm.	6	12
M. A. Humidity (per cent)	77	55
No. of years	40	60

5. GENERAL FLORISTICS

The tallest trees are typically conifers, usually *Abies*, less commonly *Juniperus*, with *Pinus wallichiana* often present and sometimes predominant. *Larix* also occurs over a restricted area.

(In the west, the *Abies* is typically the high level species, *A. spectabilis* in contradistinction to the low level *A. pindrow* of the moist temperate fir forests immediately below it.)

Betula utilis is very generally present as the largest deciduous tree and is associated with temperate deciduous genera such as *Sorbus*. In the outer moister regions, with a summer monsoon, *Quercus semecarpifolia* is also often present. *Rhododendron* is the most characteristic genus of the formation, *R. campanulatum* being the most widespread species extending from Kashmir to the N. E. Frontier. Other genera widely represented are *Viburnum*, *Lonicera*, *Berberis*, *Ribes*, *Polygonum* and *Salix*.

MOHAN (1955) has listed the typical grasses.

6. SUBDIVISIONS, SUCCESSION, ETC.

The only subdivision that appears possible on a climatic or altitudinal basis is that into a generally lower zone in which the conifers predominate, and an upper form in which they are only occasional or absent, but they extend down to the lower limit of the broad-leaved formation and into the *Quercus-Abies* associations of the temperate belt making it apparent that the development of the high forest is largely determined by site factors other than microclimate, itself largely conditioned by the general climate of the zone.

C1. *West Himalayan sub-alpine birch/fir forests (Betula/Abies).*

1a. *West Himalayan sub-alpine fir forest.*

1b. *West Himalayan sub-alpine birch/fir forest.*

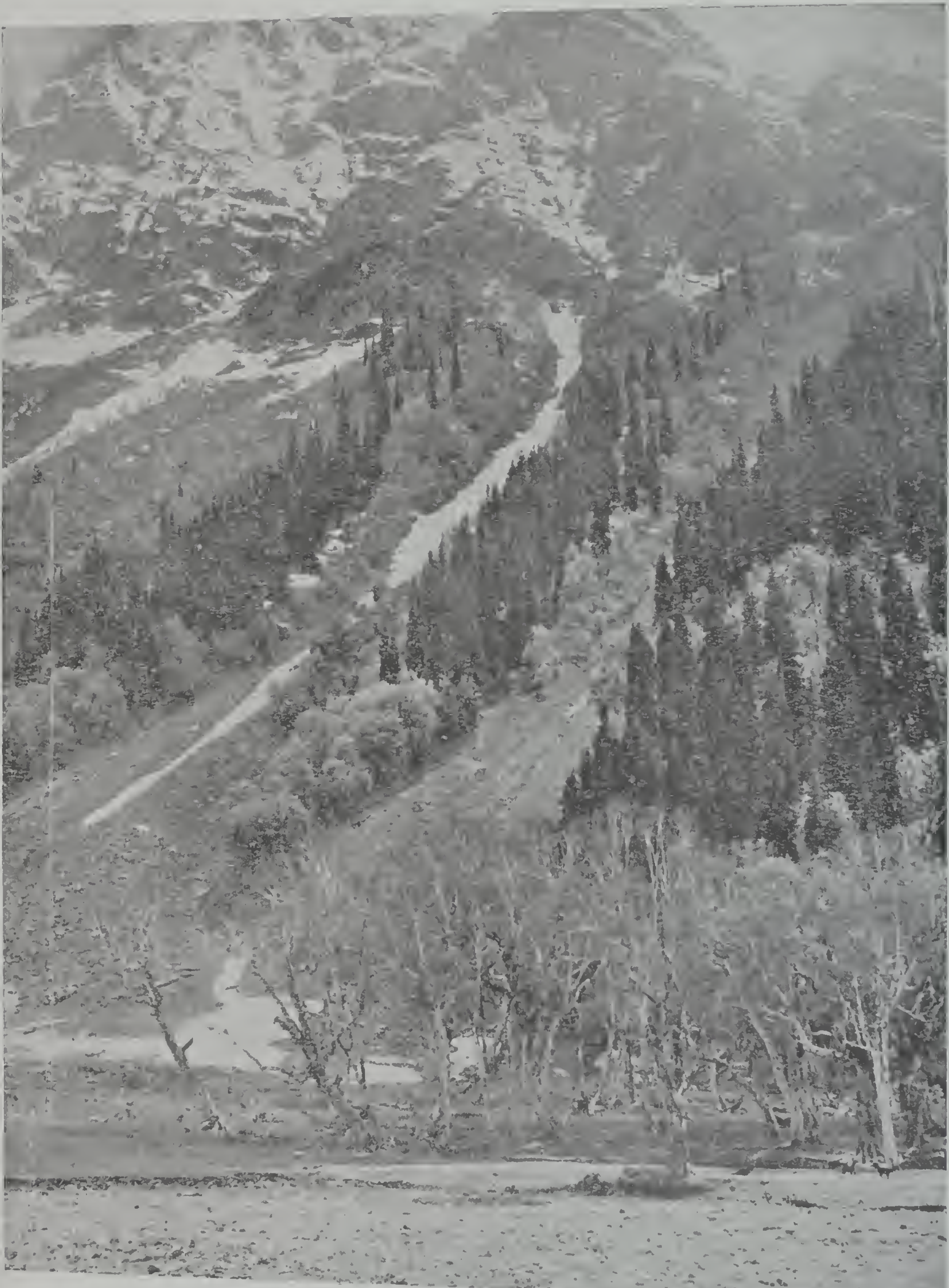
C2. *East Himalayan sub-alpine birch/fir forest.*

2S1. [*Sub-alpine blue pine forest* (*P. wallichiana*)].

C1. West Himalayan sub-alpine birch/fir forests

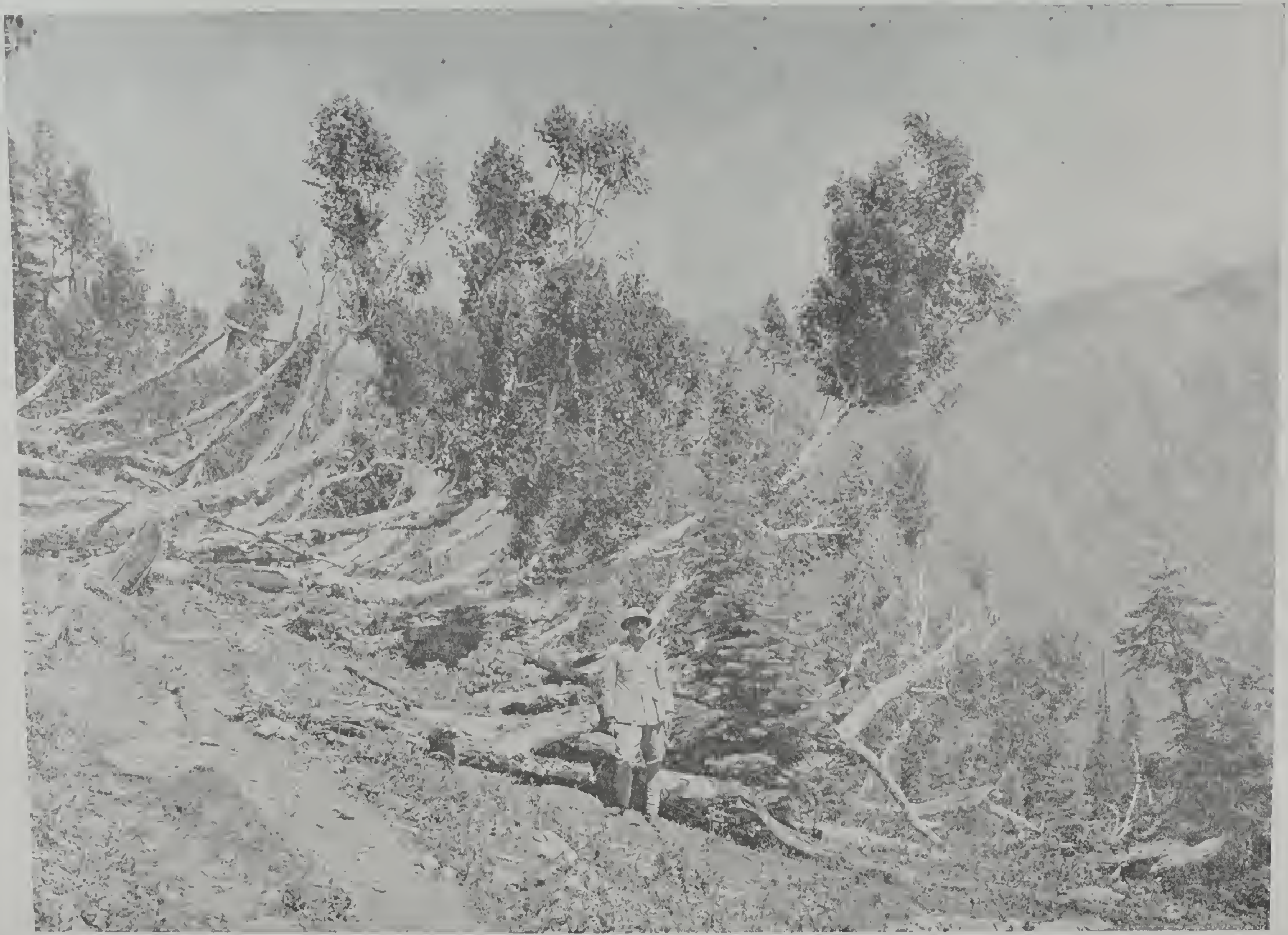
DESCRIPTION.—An irregular forest consisting very largely of three elements, fir, birch and *Rhododendron* in very varying proportions. Pure dense crops of the silver fir may occur particularly in the N.W. Himalaya but the most usual form is an open crop of the fir, with birch between and a dense undergrowth of *Rhododendron* with a varying amount of small shrubs in and under the latter. The overwood is often absent locally especially in hollows, leaving more or less pure *Rhododendron*. Blue pine may occasionally be met with and in the moist zone *Quercus semecarpifolia* may extend up into this type, as also dwarf bamboo.

DISTRIBUTION.—The western part of the Himalayas above 3,000 m. tending except in the moist zone to be limited to northern aspects. Usually on ridges and slopes where snow slides are not of frequent occurrence.



WEST HIMALAYAN SUBALPINE BIRCH/FIR FOREST

Betula utils (bottom with *Abies spectabilis* and deciduous species (*Prunus padus*, *Acer*) on slopes. Thajwas, Sonamarg, Jammu & Kashmir. *H. G. Champion*



WEST HIMALAYAN SUBALPINE BIRCH/FIR FOREST

LOCALITY FACTORS.—Those of the formation.

ILLUSTRATIONS.—Plates 97 and 98.

FLORISTICS.—

C1a. West Himalayan sub-alpine high level fir forest

(i) *Tosnal Parbatti Valley, Kulu Division, Punjab, Preservation Plot No.* 5, *N. aspect at* 2,900—3,000 m.—

I. *Abies spectabilis** (a), *Pinus wallichiana* (o), *Picea smithiana.*

II. *Rhododendron campanulatum* (la), *Taxus baccata* (lf), *Prunus padus* (f).

III. *Strobilanthes atropurpureus* (va), *Smilax vaginata, Viburnum foetens* (o), *Deutzia corymbosa* (o), *Ribes* sp., *Berberis* sp.

IVa. *Smilacina* (va), *Trillium* (a), *Anemone obtusiloba* (l), *Osmunda claytoniana* (la), *Lastrea barbata* (a), *Geranium emodi* (f).

V. *Clematis montana* (r).

NOTE.—This plot is representative of fairly extensive dense patches of high level fir without birch or much *Rhododendron* forming the transition to the moist mixed coniferous type. There is evidence that the present crop originated about 1830 after a severe fire in a predominently blue pine stand.

(ii) *Above Chini, U. Bashahr, Punjab.* 3,050 m. —

I. *Abies spectabilis** (la), *Pinus wallichiana* (a).

III. *Rhododendron campanulatum* (la), *R. lepidotum* (la), *Berberis* sp. (a), *Juniperus wallichiana* (la).

IVa. *Osmunda claytoniana, Anemone* sp., *Viola patrinii.*

Par. *Arceuthobium minutissimum* (f).

C1b. West Himalayan birch/fir forest

(i) *Thajwas, Sindh Valley, Kashmir,* 3,350 m. —

*Betula utilis** (to 1·75 m. girth), *Abies spectabilis** (a), *Pinus wallichiana* (a).

(ii) *N. Garhwal.* (OSMASTON). —

I. *Abies spectabilis** (a).

II. *Betula utilis** (a), *Quercus semecarpifolia* (o), *Rhododendron campanulatum** (a), *Sorbus foliolosa* (a).

IIa. *Thamnocalamus (Arundinaria) spathiflorus* (la).

III. *Cotoneaster acuminata, Rosa sericea, Ribes glaciale, R. rubrum, Lonicera* spp., *Rubus niveus, Smilax vaginata.*

C2. East Himalayan sub-alpine birch/fir forest

DESCRIPTION.—As for C1(a).

DISTRIBUTION.—The eastern part of the Himalayas above 3,000 m.

LOCALITY FACTORS.– Rainfall heavier and better distributed than in the western counterpart, temperature range probably somewhat less.

ILLUSTRATION.—Plate 99.

FLORISTICS.—

Gompatung Chu, Sikkim, 2,800 m.—

I. *Abies densa** (la), *Juniperus wallichiana* (lf).

II. *Rhododendron wightii* (?) (va), *Betula utilis** (f), *Rhododendron* spp. (f), *Pyrus aucuparia* (f), *Salix wallichiana* (lf).

III. *Spiraea* sp., *Juniperus recurva* (lo), *Cassiope fastigiata* (r), *Rhododendron lepidotum* (o), *Potentilla fruticosa* (o), *Polygonum* sp. (f).

NOTE.—The sub-alpine forests of the upper valleys in N. E. Sikkim and N.E.F.A., where *Larix griffithiana* and *Picea spinulosa* occur may belong here but have tentatively been included with the Dry temperate forests, cf. p. 329.

The *Rhododendrons* extend well down into the moist and wet temperate forests and their presence even in abundance does not necessitate reference to this forest type. The species of the lower elevations are mostly different, though a few are very adaptable and extend over very wide altitudinal range.

GENERAL SERAL AND DEGRADED TYPES OF SUB-ALPINE FORESTS

1*S*1. (*Hippophae/Myricaria brakes*).

1*S*2. (*Deciduous sub-alpine scrub*).

2*S*1. *Sub-alpine blue pine forest* (*P. wallichiana*).

*DS*1. *Sub-alpine pastures.*

1S1. (Hippophae/Myricaria brakes)

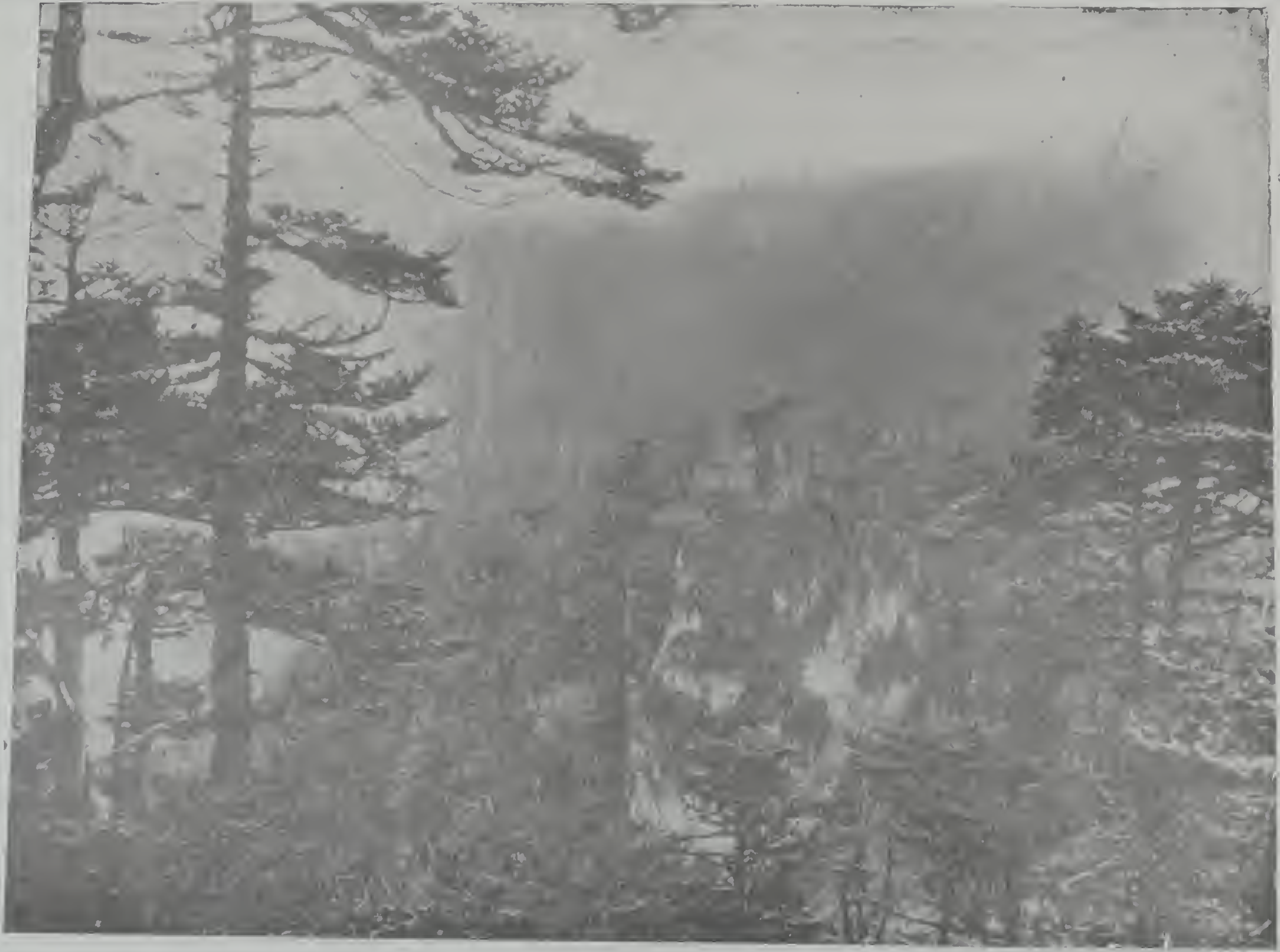
The type has been described under Type 13/1S1, page 330.

1S2. (Deciduous sub-alpine scrub)

The type is described later under Type 15/C2, page 339.

2S1. Sub-alpine blue pine forest (P. wallichiana)

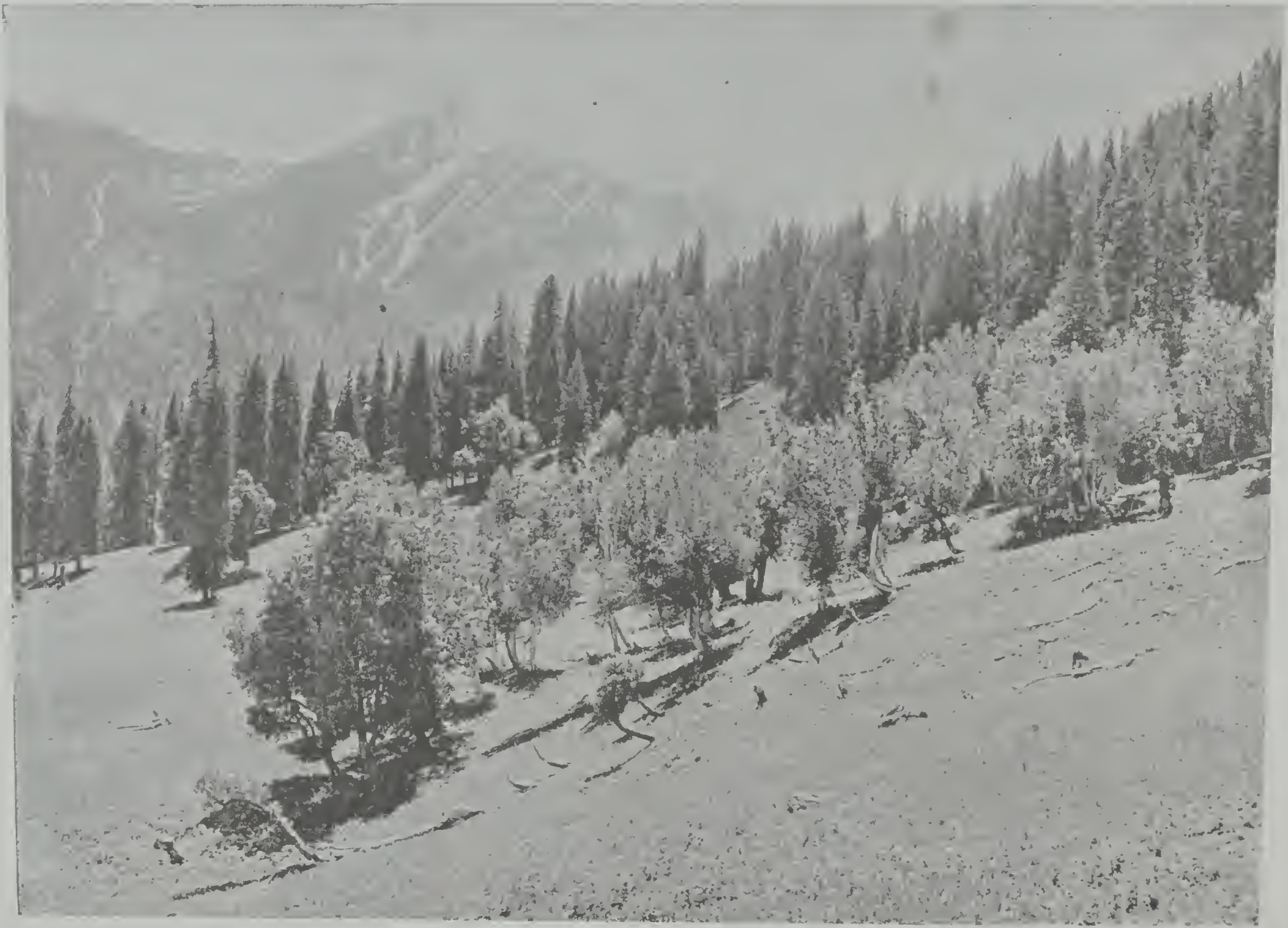
The blue pine crops which are a feature near the timber line in Kashmir, the Punjab and Himachal Pradesh, particularly in the inner drier tracts, have already been referred to in the account of the temperate forests. Their seral status seems equally definite, regeneration only occurring where the progression is thrown back by new snow or earth slides, or sometimes fire; otherwise the fir gradually displaces it. Good examples are



EAST HIMALAYAN SUBALPINE BIRCH/FIR FOREST

Abies densa with *Rhododendron* spp. underwood at 3300 m. near Sandakaphu, Darjeeling Division, West Bengal.

F. Trafford



SUBALPINE PASTURES

Open *Abies spectabilis*, *Acer* spp. and *Betula utilis* forest. Zaiwan, Jammu & Kashmir. *A. L. Griffith*

7 FRI&C/65]

available in the Parbatti Valley, Kulu. They do not differ basically from the seral blue pine forests occurring throughout the temperate altitudinal zone and are sometimes of excellent height and density (*e.g.* Tosnal) though *Arceuthobium* infestation is liable to be heavy. Preservation Plot No. 2, Kulu Division, is a good example of such a blue pine crop dating from about 1800 A.D. progressing to Silver fir.

ILLUSTRATION.—OSMASTON (1922); Pl. X.

DS1. Sub-alpine pastures

RAINA (1959) has listed the grasses predominating in the subalpine and alpine pastures, viz. *Agropyron longearistatum*, *A. semicostatum*, *Brachypodium sylvaticum*, *Bromus asper*, *B. japonicus*, *Dactylis* sp., *Danthonia* sp., *Festuca* sp., *Milium effusum*, *Oryzopsis*, *Phleum*, *Poa* spp. etc.

ILLUSTRATION.—Plate 100.

CHAPTER XI

ALPINE SCRUB

GROUP 15. MOIST ALPINE SCRUB

C1. Birch-Rhododendron scrub forest

NOMENCLATURE.—Subalpine forest (*Rhododendron*). (SCHWEINFURTH).

DESCRIPTION.—As described in the E. Himalaya, this type forms a low evergreen forest almost entirely of species of *Rhododendron* but with some birch and other deciduous trees, so dense as to be difficult to penetrate, particularly in an uphill direction as owing to snow pressure, the stems all curve up from a more or less horizontal or downward bent base. Trunks are short and branchy and rarely much over 60 cm. in girth. Moss or ferns cover the ground with varying amounts of alpine shrubs, flowering herbs and ferns. The western form is generally similar but is not so well differentiated from the birch-fir forest and does not dominate over such extensive tracts. The birch may form almost pure stands above the last fir.

DISTRIBUTION.—The whole length of the Himalayas and on the highest hills near the Burma border, limited in the west to sheltered sites usually on northern and western aspects, becoming more general eastwards.

LOCALITY FACTORS.—The chief characteristic is an ample snowfall, the snow lying till the day air temperature is quite warm. The growth habit of the *Rhododendron* is well adapted to stand snow pressure and even sliding snow. A thick layer of black humus is typically present and the soil is generally wet.

ILLUSTRATION.—Plate 101.

FLORISTICS.—

(i) *Thajwas, Sindh Valley, Kashmir.* 3,600 m.—

*Betula utilis**.

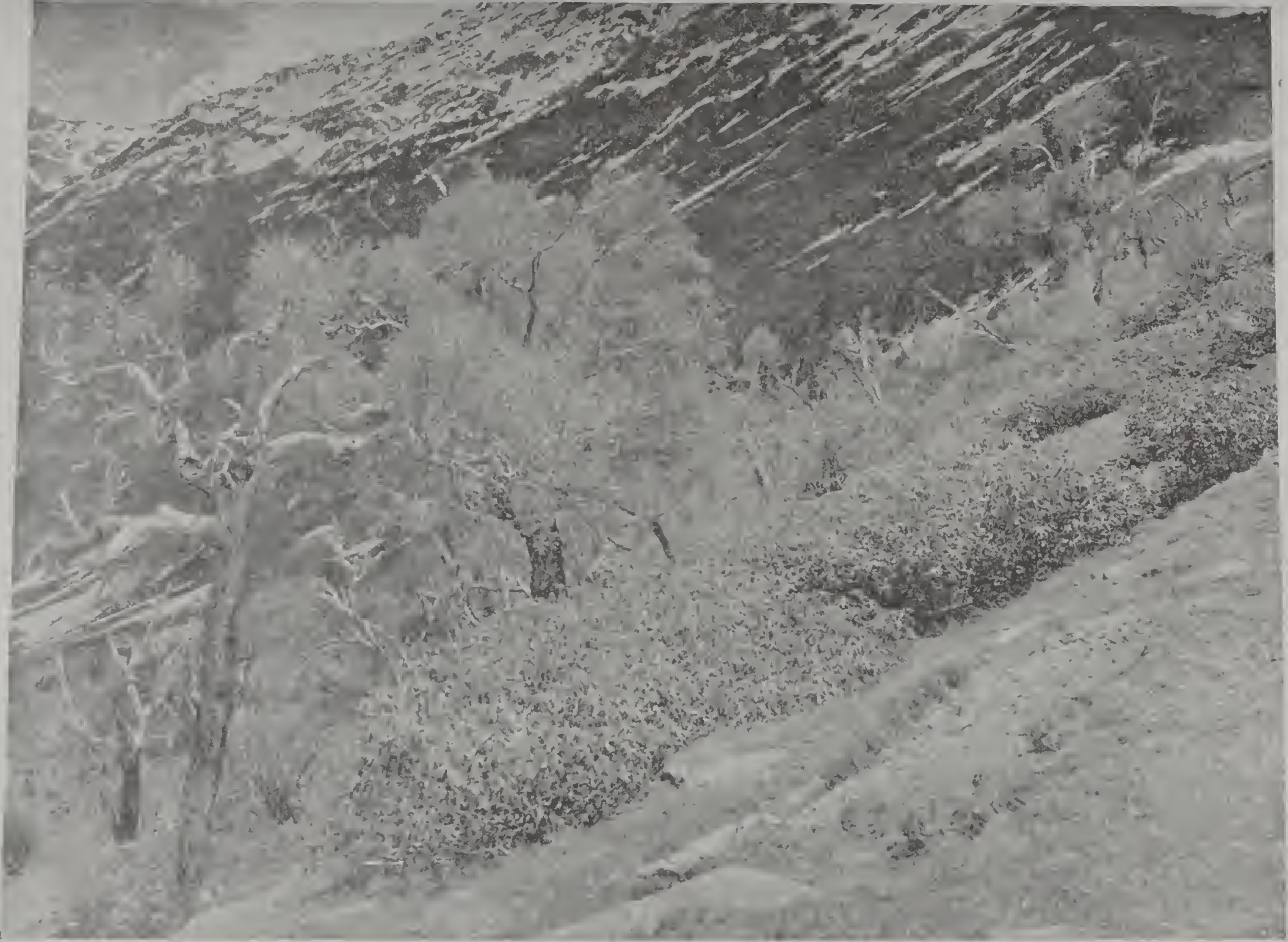
NOTE.—The type extends downwards meeting the mixed deciduous forest in the valleys and an almost pure birch stand exists on recent gravel in the valley bottoms; the species also struggles still further down fringing the cold mountain torrents.

(ii) *Sunderdhunga Valley, W. Kumaon, U.P.* 3,800 m.—

I. *Betula utilis** (a), *Rhododendron campanulatum* (a), *Sorbus foliolosa* (f).

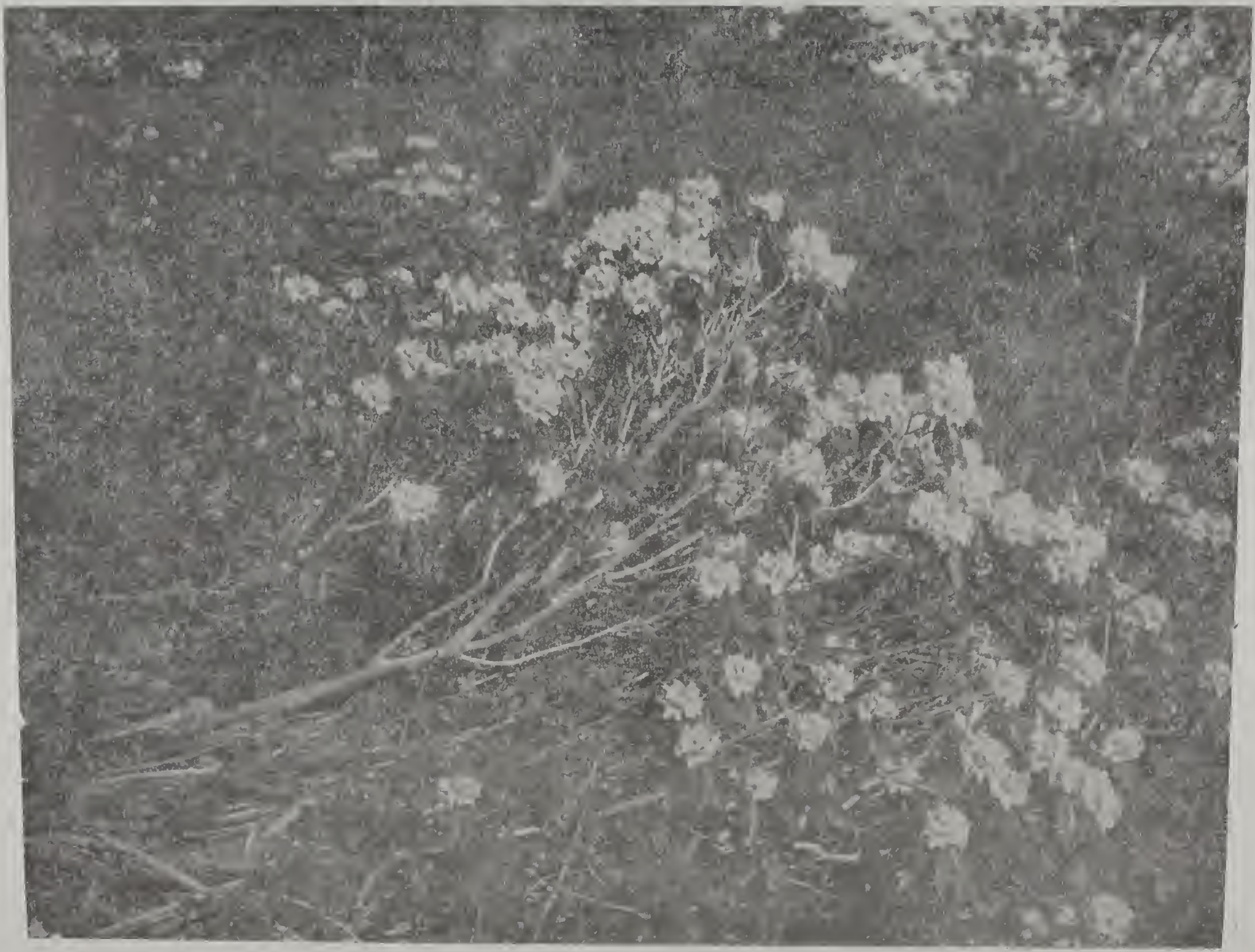
II. & III. *Viburnum nervosum* (f), *Rhododendron lepidotum* (o), *Berberis* spp. (f), *Lonicera parviflora* (f), *Gaultheria trichophylla* (lf).

IVa. *Primula denticulata* (va), *P. stuartii* (o), *Corydalis stracheyi*, *Macrotomia benthami*.



BIRCH/RHODODENDRON SCRUB FOREST

Betula utilis, *Rhododendron campanulatum*, the former much damaged by snow and unthrifty. Near tree limit 3500 m. Hiranghtti, Upper Bashahr Division, Himachal Pradesh. *M. V. Laurie*



DECIDUOUS ALPINE SCRUB

Rhododendron campanulatum and deciduous shrubs bent by snow; near tree limit 3500

(iii) *Garhwal, U.P.* (OSMASTON)—

I. & II. *Rhododendron campanulatum, Sorbus foliolosa, Betula utilis, Quercus semecarpifolia.*

III. *Berberis* sp., *Cotoneaster* sp., *Lonicera* spp., *Polygonum vaccinifolium, Rhododendron lepidotum.*

NOTE.—The predominant species of the shrub genera vary with the moistness of the micro-climate. OSMASTON differentiates a *Rhododendron-Lonicera* shrub association from a *Betula-Abies* tree association, but includes in the former the decidedly different dwarf *Rhododendron* scrub here relegated to a separate formation.

(iv) *Dzongri Ridge, Sikkim,* 3,800 m.—

I. *Rhododendron wightii** (?) (va), *R. campanulatum* (f), *R. molle* (?) (f), *R. thomsoni* (lf), 2 other large spp.

II. *Rhododendron setosum* (o), *R. anthopogon* (o), *R. lepidotum* (o), *Berberis* spp.

III. *Primula stuartii.*

(v) *Rhododendron-Betula hylium* (DEB) ; *Peaks over* 2,400 m. *in Manipur.*—

I. & II. *Rhododendron** spp., *Quercus semecarpifolia, Betula utilis*, Pyrus* spp.

III. *Berberis* spp., *Mahonia* spp., *Hypericum* spp., *Spiraea* spp.

IVa. *Iris* etc.

V. *Clematis* spp.

C2. Deciduous alpine scrub

No detailed description of this formation is necessary as it is not a tree forest type. As, however, it extends down into the sub-alpine forest last described, it is necessary to give a brief account of it.

DESCRIPTION.—A low deciduous scrub formation usually only about 1 m. high forming a dense cover continuous over extensive areas but broken up by grass, probably often secondary as the result of grazing and shrub cutting for firewood. Outlying patches of the subalpine forest, chiefly in the form of colonies of *Betula* and the larger *Rhododendrons*, may occur, but the growth is often very uniform. Extensive patches (societies) of dwarf *Rhododendron* and of dwarf Junipers may be distributed in relation to varying site conditions particularly seasonal moisture variations.

DISTRIBUTION.—The whole length of the Himalayas at elevations above about 3,350 m. occasionally extending lower, and adjoining the sub-alpine and upper temperate forests.

LOCALITY FACTORS.—The climate is usually too cold and severe for tree growth. The precipitation is usually rather limited in total amounts ; it comes particularly in the W. Himalaya, mostly as snow which covers the ground for 5 or 6 months and locally onger so that the growing season is very short.

ILLUSTRATION.—Plate 102.

FLORISTICS.—

(i) *Aparwat, Pir Panjal, Kashmir.* 3,700 m.—

I. & II. *Betula utilis.*

III. *Syringa emodi*, Salix* sp., *Lonicera* sp., *Berberis* sp., *Rosa* sp.

IVa. *Aconitum* spp., *Trollius.*

E1. Dwarf Rhododendron scrub

Western Himalayas

OSMASTON (1922) described the following consociations in the *Rhododendron-Lonicera* associations (his *Betula-Rhododendron* formation) for Garhwal, in the Inner Himalayas.

(i) *Rhododendron hyperanthum** (*anthopogon*), 15 cm. to 50 cm. high, in moist dry and arid zones chiefly in northern aspects in continuous more or less dense patches upto 20 hectares in extent, generally on rough boulder strewn ground but shunning steepest rocky places, at altitudes of 3,200 m. to 4,100 m. Sometimes mixed with *R. lepidotum, Salix lindleyana, S. fruticulosa, Lonicera obovata* on dry north aspects.

(ii) *Rhododendron lepidotum**, 15 cm. to 1 m. high, in moist dry and arid zones, in open consociations upto a few hectares, on north but typically on dry southern aspects (where it replaces *R. anthopogon*) at 2,600 m. to 4,000 m.

(iii) *Rhododendron campanulatum**, 1.5 m. to 3 m. high in dense thickets upto 25 hectares in extent, chiefly in dry and arid zones, mixed with varying proportion of *Sorbus foliolosa* lower down but pure at 3,350 m. to 3,800 m.

ILLUSTRATION.—Plate 102.

NOTE.—Average precipitation varies from 250 m. to 2,000 mm., mostly as snow. The factors that determine the relative distribution of the mixed deciduous scrub and the dwarf *Rhododendrons* has not yet been determined but they appear to be edaphic. Similarly, the dwarf Juniper consociations seem to be on the more freely drained drier sites and so are described under the next group.

Eastern Himalayas

In the Eastern Himalayas dense *Rhododendron* thickets occur at 3,350 m. to 4,600 m. changing into scrub at the upper limit, dominant at 4,600 to 4,900 m. and ascending upto 5,500 m. on dry southern slopes.

*Rhododendron campanulatum** with or without *R. wightii* occurs at 3,350 to 4,300 m., *R. campylocarpum* and *R. pumilum* also heavily found. *R. lepidotum* and *R. hypenanthum* occupy the highest belt but *R. campanulatum, R. setosum, R. lanatum* may also grow upto 4,600 to 4,900 m. *R. nivale* occurs last of all in very cold regions, also in rocks in glaciericе (SMITH and CAVE; GAMMIE).

DRY ALPINE SCRUB

Mat plants of *Juniperus* sp. on northern slopes at 3100 m, Koksar, Lahul, Punjab — *N. L. Bor*

E2. (Dwarf Juniper scrub)

This is described under 16/E1, below.

C3. Alpine pastures

These are continuous with those lower down and differ only in having a shorter snow-free period and in floristic detail. (p. 337).

The meadows are composed mostly of perennial mesophytic herbs, with very little grass. Conspicuous among the herbs are *Primula*, *Anemone*, *Fritillaria*, *Iris*, *Gentiana*, with many *Ranunculaceae*, *Cruciferae*, *Caryophyllaceae* and *Compositae*.

GROUP 16. DRY ALPINE SCRUB

C1. Dry alpine scrub

Mention of this type is only included for the sake of completeness.

The type is widespread in the inner ranges as in W. Tibet behind Kumaon, extending into India in U.P. (OSMASTON), Himachal Pradesh, the Punjab and Kashmir. It adjoins the dry temperate forests and may take their place under heavy pressure of grazing etc. SCHWEINFURTH describes it as *Alpine Steppe*.

It is very often xerophytic formation in which dwarf shrubs predominate and is met with in the Tibetan areas with rainfall probably always under 370 mm. Characteristic plants are *Eurotia ceratoides** (mainly Tibetan), *Juniperus wallichiana* and *J. communis*, *Caragana* spp., *Artemisia maritima**, *A. sacrorum*, *Lonicera* spp., and *Potentilla* spp. (cf. OSMASTON, 1922). The dwarf Juniper patches in the moist zone may be viewed as outliers.

A characteristic vegetation occurs along streams in which *Salix*, *Myricaria* and *Hippophae* are the typical genera and form a fairly complete cover 1-3 m. high. The *Hippophae* is *H. rhamnoides* not *H. salicifolia* (cf. Type 13/1S1 described on p. 330).

ILLUSTRATION.—Plate 103.

Higher up the scrub gives place to stony desert only with herbs such as *Sedum crassipes*, *Androsace*, *Primula minutissima*, *Saxifraga imbricata* (5,800 m.), *Sedum crenulatum*, *Leontopodium*, *Arenaria* (6,000 m.). *Callianthemum kashmerianum*, *Draba gracillima* (5,800 m.), *Potentilla fruticosa* var. *inglesii* (6,000 m.), *Kobresia duthei* (5,500 m.). *K. capellifolia* (5,800 m.). (SAHNI).

E1. Dwarf Juniper scrub

Western Himalayas

OSMASTON (1922) has described the following consociations : (*Caragana-Lonicera-Artemisia* formation; *Caragana-Artemisia* association) for the Garhwal Himalayas.

(i) *Juniperus communis*, about 0·6 m. high, in more or less compact patches of a few square metres at 2,900 m. to 4,250 m.

(ii) *Juniperus wallichiana*, with low spreading branches 30 cm. to 1.5 m. high, in dense patches upto 0·2 hectares in extent, at 2,900 m. to 4,200 m.

NOTE.—This type occurs on very dry sites exposed to intense insolation during the short growing season. The annual precipitation is mostly in the form of snow and may not exceed 250 mm. The soil is dry sandy and loose and easily transported by wind. Scattered herbs occur but grasses are absent.

Eastern Himalayas

In the Eastern Himalayas *Juniperus recurva* (3,000 to 4,600 m.) and *J. recurva* var. *squamata* (4,300 to 4,900 m.) succeed *J. wallichiana* at about 4,300 m., especially on screes, and ascend upto 4,900 m. The associations are purer at higher elevations.

APPENDIX A

FOREST TYPES OCCURRING IN EACH STATE

Andamans and Nicobar Islands—

1A/C1.	Giant evergreen forest—(p. 62).
1A/C2.	Andamans tropical evergreen forest—(p. 63).
1A/C3.	Southern hilltop tropical evergreen forest—(p. 64).
1/E1.	Cane brakes—(p. 79).
1/E2.	Wet bamboo brakes—(p. 101).
2A/C1.	Andamans semi-evergreen forest—(p. 85).
3A/C1.	Andamans moist deciduous forest—(p. 103).
3A/C1/2S1.	Andamans secondary moist deciduous forest—(p. 104).
4A/L1.	Littoral forest—(p. 155).
4B/TS.	Tidal swamp forest—(pp. 163-166).
4C/FS2.	Submontane hill valley swamp forest—(p. 167).

Andhra Pradesh—

3B/C1(b,c).	Slightly moist and moist teak forest—(pp. 115, 116).
3B/C2.	Southern moist mixed deciduous forest—(p. 117).
3B/2S1.	Southern secondary moist mixed deciduous forest —(p. 119).
3C/C2(e).	Moist peninsular sal—(pp. 143-145).
4A/L1.	Littoral forest—(p. 155).
4B/TS.	Tidal swamp forest—(pp. 163-166).
5A/C1(b).	Dry teak forest—(p. 182).
5A/C2.	Dry red sanders-bearing forest—(p. 185).
5A/C3.	Southern dry mixed deciduous forest—(p. 185).
5B/C1(c).	Dry peninsular sal forest—(p. 198).
5/DS1.	Dry deciduous scrub—(p. 205).
5/DS2.	Dry savannah forest—(p. 207).
5/DS3.	*Euphorbia* scrub—(p. 208).
5/DS4.	Dry grassland —(p. 209).
5/E2.	*Boswellia* forest—(p. 212).
5/E4.	*Hardwickia* forest—(p. 215).
5/E7.	Laterite thorn forest—(p. 217).
5/E9.	Dry bamboo brake—(p. 220).
5/1S1.	Southern dry tropical riverain forest—(p. 221).
5/2S1.	Secondary dry deciduous forest—(p. 225).
6A/C1.	Southern thorn forest—(p. 229).
6A/C2.	Carnatic umbrella thorn forest—(p. 232).
6A/DS1.	Southern thorn scrub—(p. 233).
6A/DS2.	Southern *Euphorbia* scrub—(p. 233).
6/DS1.	*Cassia auriculata* scrub—(p. 245).
7/C1.	Tropical dry evergreen forest—(p. 246).
7/DS1.	Tropical dry evergreen scrub—(p. 250).

Assam (including NEFA. Nagaland, Sikkim and Bhutan)—

1B/C1.	Assam valley tropical wet evergreen forest—(p. 76).
1B/C2(a,b).	Upper Assam valley tropical evergreen forest —(p. 77).

1B/C3.	Cachar tropical evergreen forest—(p. 78).
1/E1.	Cane brakes—(p. 79).
1/E2.	Wet bamboo brakes—(p. 80).
1/2S1.	Pioneer Euphorbiaceous scrub—(p. 80).
2B/C1(a,b).	Assam valley semi-evergreen forest—(pp. 92, 94).
2B/C1/1S1.	Sub-Himalayan high alluvial semi-evergreen forest—(p. 95).
2B/C1/1S2.	*Syzygium* parkland—(p. 96).
2B/C1/2S2.	Eastern alluvial secondary semi-evergreen forest—(p. 96).
2B/C/2S3.	Sub-Himalayan secondary wet mixed forest—(p. 98).
2B/C2.	Cachar semi-evergreen forest—(p. 99).
2/E3.	Moist bamboo brakes—(p. 101).
2/2S1.	Secondary moist bamboo brakes—(p. 102).
3C/C1(a,b,c).	Very moist sal forest—(pp. 127, 128, 130, 131, 133, 134).
3C/C2(d).	Moist plains sal forest—(p. 139).
3C/C2/DS1.	Moist sal savannah—(p. 146).
3C/C3(b).	East Himalayan moist mixed deciduous forest—(p. 149).
3C/C3/2S1.	Northern secondary moist mixed deciduous forest—(p. 150).
3C/C3/2S2.	Secondary Euphorbiaceous scrub—(p. 151).
3/1S1.	Low alluvial savannah woodland—(p. 152).
3/1S2(a,b).	Eastern *hollock* forest—(p. 154).
4C/FS2.	Sub-montane hill valley swamp forest—(p. 167).
4C/FS3.	Creeper swamp forest—(p. 168).
4D/SS1 to SS5.	Tropical seasonal swamp forest—(pp. 169-171).
4D/2S2.	Eastern wet alluvial grassland—(p. 172).
4E/RS1.	Riparian fringing forest—(p. 173).
5/1S2.	*Khair-sissu* forest—(p. 222).
8B/C2.	*Khasi* sub-tropical hill forest—(p. 265).
8B/DS1.	Assam sub-tropical hill savannah woodland—(p. 267).
9/C2(8B/2S1).	Assam sub-tropical pine forest—(pp. 266, 274).
9/C2/DS1.	Assam sub-tropical pine savannah—(p. 275).
11B/C1(a,b,c).	East Himalayan wet temperate forest—(pp. 286 288).
11B/C2.	Naga hills wet temperate forest—(p. 288).
12/C3(a,b).	East Himalayan moist temperate forest—(pp. 314-316).
12/E1.	Cypress forest—(p. 318).
12/DS1.	Montane bamboo brakes—(p .316).
12/1S1.	Alder forest—(p. 319).
12/2S1.	Low level blue-pine forest—(p. 320).
13/C6.	East Himalayan dry temperate coniferous forest—(p. 328).
13/C6/E1.	Larch forest—(p. 329).
13/C7.	East Himalayan dry juniper/birch forest—(p. 329).
13/1S1.	*Hippophae/Myricaria* scrub.—(p. 330).
14/C2.	East Himalayan sub-alpine birch/fir forest—(p. 336).
14/C2/2S1.	Sub-alpine blue pine forest—(p. 336).
14/DS1.	Sub-alpine pasture—(p. 337).
15/C1.	Birch/*Rhododendron* scrub—(p. 338).
15/C2.	Deciduous alpine scrub—(p. 339).
15/C2/E1.	Dwarf *Rhododendron* scrub—(p. 340).
16/C1.	Dry alpine scrub—(p. 341).
16/E1.	Dwarf juniper scrub—(p. 341).

Bihar—

2/E3.	Moist bamboo brakes—(p. 101).
3C/C2(a,b,c).	Moist Siwalik, bhabar and peninsular sal forest—(pp. 136, 137, 138, 143, 144, 145).

3C/DS1.	Moist sal savannah—(p. 146).
3C/C3(a).	West Gangetic moist mixed deciduous forest—(p. 147).
3C/2S1.	Northern secondary moist mixed deciduous forest—(p. 150).
3/E1.	*Terminalia tomentosa* forest—(p. 151).
3/1S1.	Low alluvial savannah woodland (*Bombax-Albizzia*)—(p. 152).
4C/FS2.	Sub-montane hill valley swamp forest—(p. 167).
4D/SS3.	*Syzygium cumini* swamp low forest—(p. 170).
4E/RS1.	Riparian fringing forest—(p. 173).
5B/C1(c).	Dry peninsular sal forest—(p. 198).
5B/C2.	Northern dry mixed deciduous forest—(p. 200).
5B/DS1.	Dry deciduous scrub—(p. 205).
5B/DS2.	Dry savannah forest—(p. 207).
5B/DS3.	*Euphorbia* scrub—(p. 208).
5B/DS4.	Dry grassland—(p. 209).
5/E1.	*Anogeissus pendula* forest—(p. 210).
5/E2.	*Boswellia* forest—(p. 212).
5/E5.	*Butea* forest—(p. 215).
5/E6.	*Aegle* forest—(p. 216).
5/E8.	Saline/alkaline scrub savannah—(p. 218).
5/E9.	Dry bamboo brake—(p. 220).
5/1S1.	Southern dry tropical riverain forest—(p. 221).
5/1S2.	*Khair-sissu* forest—(p. 222).
5/1S3.	Inundation *babul* forest—(p. 224).
5/2S1.	Secondary dry deciduous forest—(p. 225).
6B/C2.	Ravine thorn forest—(p. 240).
6B/DS1.	*Zizyphus* scrub—(p. 242).
6B/DS2.	Tropical *Euphorbia* scrub—(p. 242).
8A/C3.	Central Indian subtropical hill forest—(p. 257).

Gujarat—

3B/C1(b,c).	Slightly moist and moist teak forest—(pp. 115, 116).
3B/C2.	Southern moist mixed deciduous forest—(p. 117).
3B/2S1.	Southern secondary moist mixed deciduous forest—(p. 119).
4A/L1.	Littoral forest—(p. 155).
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10/C1/DS1.	*Dodonaea* scrub—(p. 277).
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5B/C2.	Northern dry mixed deciduous forest—(p. 200).
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5/E2.	*Boswellia* forest—(p. 212).
5/E5.	*Butea* forest—(p. 214).
5/E6.	*Aegle* forest—(p. 216).
5/E9.	Dry bamboo brakes—(p. 220).
5/DS1.	Dry deciduous scrub—(p. 205).
5/DS2.	Dry savannah forest—(p. 207).

5/DS3, 6B/DS2. 6/E1.	*Euphorbia* scrub — pp. 208, 242, 243).
5/DS4.	Dry grassland—(p. 209).
5/1S1.	Dry tropical riverain forest—(p. 221).
5/2S1.	Secondary dry deciduous forest—(p. 225).
6B/C1.	Desert thorn forest—(p. 239).
6B/DS1.	*Zizyphus* scurb —(p. 242).
6/E2.	*Acacia senegal* forest—(p. 244).
6/E4.	*Salvadora scrub*—(p. 244).
6/E4/DS1.	*Cassia auriculata* scrub— (p. 245).
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Uttar Pradesh—

2/E1.	(Cane brakes)—(p. 101).
2/E3.	Moist bamboo brakes—(p. 101).
2/2S1.	Secondary moist bamboo brakes— (p. 102).
3C/C2(a to e).	Moist sal-bearing forest—(pp. 135, 136, 137, 138, 139-145).
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3C/C3/2S1.	Northern secondary moist mixed deciduous forest— (p. 150).
3/E1.	*Terminalia tomentosa* forest— (p. 151).
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5A/C3.	Southern dry mixed deciduous forest— (p. 185).
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5B/C2.	Northern dry mixed deciduous forest— (p. 200).
5/DS1.	Dry deciduous scrub— (p. 205).
5/DS2.	Dry savannah forest—(p. 207).
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5/E1.	*Anogeissus pendula* forest— (p. 210).
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5/E2.	*Boswellia* forest— (p. 212).
5/E3.	*Babul* forest— (p. 214).
5/E5.	*Butea* forest— (p. 215).
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5/E8.	Saline/alkaline scrub savannah— (p. 21
5/E9.	Dry bamboo brakes—(p. 220).
5/1S2.	*Khair-sissu* forest— (p. 222).
5/1S3.	Inundation *babul* forest— (p. 224).
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6B/C1.	Desert thorn forest —(p. 239).
6B/C2.	Ravine thorn forest — (p. 240).
6B/DS1.	*Zizyphus* scrub — (p. 242).
6B/DS2.	Tropical *Euphorbia* scrub — (p. 242).
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9/C1(a,b).	Himalayan sub-tropical pine forest— (pp. 270, [illegible]).
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9/C1/DS2.	Sub-tropical *Euphorbia* scrub — (p. 274).
10/C1(a).	*Olea cuspidata* scrub forest—(p. 27
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12/C1/DS2.	Himalayan temperate secondary scrub—(p.309).
12/C2(a to c).	Upper West Himalayan temperate forest—(pp.310, 312, 314).
12/DS1.	Montane bamboo brakes—(p. 316).
12/DS2.	Himalayan temperate parkland—(p. 317).
12/DS3.	Himalayan temperate pastures—(p. 318).
12/E1.	Cypress forest—(p. 318).
12/1S1.	Alder forest—(p. 319).
12/1S2.	Riverain blue-pine forest—(p. 320).
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13/C1.	Dry broadleaved and coniferous forest (*Quercus ilex*/*P. gerardiana*)—(p. 325).
13/C2(a,b).	Dry temperate coniferous forest—(pp. 325, 326).
13/C3.	(West Himalayan dry temperate deciduous forest).—(p. 327).
13/C4(13/1S3, 14/2S1).	West Himalayan high-level dry blue pine forest (*P. wallichiana*)—(pp. 328, 330, 336).
13/C5.	West Himalayan dry juniper forest—(*J. macropoda*).—(p. 328).
13/1S1.	*Hippophae*/*Myricaria* scrub—(p. 330).
13/1S2.	*Populus*/*Salix* forest—(p. 330).
14/C1(a,b).	West Himalayan sub-alpine birch/fir forest (*Betula*/*Abies*)—(pp. 334, 335).
14/C2.	East Himalayan sub-alpine birch/fir forest—(p. 336).
14/1S1.	(*Hippophae*/*Myricaria* brakes)—(p. 336).
14/1S2.	(Deciduous sub-alpine scrub)—(p. 336).
14/DS1.	Sub-alpine pastures—(p. 337).
15/C1.	Birch/*Rhododendron* scrub forest—(p. 338).
15/C2.	Deciduous alpine scrub—(p. 339).
15/C2/E1.	Dwarf *Rhododendron* scrub—(p. 340).
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16/C1.	Dry alpine scrub—(p. 341).
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West Bengal—

1/E1.	Cane brakes—(p. 79).
2B/C1/1S1.	Sub-Himalayan light alluvial semi-evergreen forest—(p. 95).
2B/C1/2S1.	(Pioneer Euphorbiaceous scrub)—(p. 96).
2/2S1.	Secondary moist bamboo brakes—(p. 102).
3C/C1(a,b,c).	Very moist hill, *bhabar* and *tarai* sal forest—(pp. 128, 130, 131, 133, 134).
3C/C2(b,e).	Moist sal-bearing forest—(pp. 137, 139).
3C/C2/DS1.	Moist sal savannah—(p. 146).
3C/C3(b).	East Himalayan moist mixed deciduous forest—(p. 149).
3C/C3/2S1.	Northern secondary moist mixed deciduous forest—(p. 150).
3/1S1.	Low alluvial savannah woodland (*Bamboo-Albizzia*)—(p. 152).
3/1S2(b).	*Terminalia*—*Duabanga*—(p. 154).
4A/L1.	Littoral forest—(p. 155).
4B/TS1 to 4.	Tidal swamp forest—(pp. 163, 166).
4B/TS/E1.	Palm swamp—(p. 166).
4C/FS2.	Sub-montane hill valley swamp forest—(p. 167).
4D/SS.	Tropical seasonal swamp forest—(pp. 169, 171).
4E/RS1.	Riparian fringing forest—(p. 173).
5B/C1(c).	Dry peninsular sal forest—(p. 198).
5B/C2.	Northern dry mixed deciduous forest—(p. 200).
5/DS1.	Dry deciduous scrub—(p. 205).
5/DS2.	Dry savannah forest—(p. 207).
5/E5.	*Butea* forest—(p. 215).
5/E8.	Saline/alkaline scrub savannah—(p. 218).

5/E9.	Dry bamboo brake—(p. 220).
5/1S2.	*Khair-sissu* forest—(p. 222).
5/2S1.	Secondary dry deciduous forest—(p. 225).
8B/C1.	East Himalayan sub-tropical wet hill forest—(p. 260).
9/C1(a,b).	Himalayan sub-tropical pine forest—(pp. 270, 272).
9/C1/DS1.	Himalayan sub-tropical scrub—(p. 274).
11B/C1 (a to c).	East Himalayan wet temperate forest—(p. 286-288).
12/C3(a).	East Himalayan mixed coniferous forest—(p. 315).
12/DS1.	Montane bamboo brakes—(p. 316).
12/DS2.	Himalayan temperate parkland—(p. 317).
12/DS3.	Himalayan temperate pastures—(p. 318).
12/1S1.	Alder forest—(p. 319).
13/C6.	East Himalayan dry temperate coniferous forest—(p. 328).
13/C6/E1.	Larch forest (*L. griffithiana*)—(p. 329).

APPEN

ANALYTICAL DATA FOR SOME

(Thornthwaite's 1948 climatic types are given. Ar=Per humid with little or no with little or no water deficiency; Bw=Humid with moderate winter water deficiency; water surplus; Cw=Sub humid with moderate summer water surplus; Dd=Semi arid

Forest Type	Locality	Altitude (metres)	Geology	Topography	Water table (metres)	Nearest Meteorological tation	Climatic type	Soil type	Depth (cm.)	Mechanical composition			
										Coarse s and %	Fine s and %	Silt %	Clay %
1	2	3	4	5	6	7	8	9	10	11	12	13	14
Andamans Tropical evergreen. (1A C2)	1939 area, Parlob Island, Middle Andamans.	16	Argillaceous sandstone with quartzite	Hill slope	3	Port Blair	Ar	Red earth	0—7	42·3	22·7	15·0	15·0
									7—30	28·5	17·2	10·0	42·5
									30—74	34·1	9·4	10·0	65·0
									74—107	11·7	18·0	17·5	42·5
									107—127	7·8	33·8	17·5	40·0
									127—165	12·6	27·1	15·0	37·5
West Coast Tropical evergreen. (1A/C4)	Block XXVII East Kanara Division, Mysore.	594	Granitic gneiss	Hill slope	6½	Mangalore	Aw	Lateritic	0—8	17·5	9·6	25·0	45·0
									8—45	17·6	9·7	17·5	52·5
									45—112	42·2	7·5	12·5	35·0
									112—178	15·7	20·0	27·5	35·0
West Coast Tropical evergreen. (1A/C4)	Comptt. 14, Silent Valley, Palghat Division, Kerala.	1220	Gneiss granite	Upper hill slope	Deep	Cochin	Bw	Lateritic	0—7	27·9	15·65	30·0	25·0
									7—36	27·6	16·1	27·5	25·0
									36—91	17·8	16·0	2·5	60·0
									91—175	23·1	13·3	10·0	50·0
Assam Valley tropical Wet evergreen (1B/C1)	Comptt. 38, U.D.R.East, Lakhimpur Division, Assam.	152	Alluvium	Alluvial plain	Deep	Dibrugarh	Br	Alluvial	0—13	22·3	26·6	45·0	5·0
									13—61	13·2	19·3	32·5	35·0
									61—117	7·8	23·9	37·5	30·0
									117—175	22·8	36·0	22·5	15·0
Slightly moist teak. (3B/C1a)	Allapalli 28, South Chanda Division, Maharashtra.	183	Gneiss & quartzite	Hill slope	10	Chanda	Cw	Red	0—23	26·5	28·0	17·5	27·5
									23—76	31·5	23·0	22·5	22·5
									76—183	58·5	23·6	5·0	7·5
Moist teak. (3B/C1b)	Bori 81-A, Hoshangabad Division, M.P.	427	Basalt	Flat undulating	Shallow	Indore	Cw	Brown earth	0—23	28·2	20·2	17·5	37·5
									23—64	22·2	18·6	22·5	30·0
									64—91	36·5	26·6	15·0	15·0
									91—122	45·7	26·6	15·0	7·5
Very moist teak. (3B/C1c)	Comptt. 158, Walluvasseri, Nilambur Division, Kerala.	30	Alluvium	Valley bottom	15	Nilambur	Bw	Alluvial	0—23	3·8	34·3	20·0	37·5
									23—61	2·7	34·9	20·0	37·5
									61—91	2·9	37·9	22·5	32·5
									91—183	2·8	34·1	35·8	27·5
Moist Siwalik Sal. (3C/C2a	Betban, Saharanpur Division, U.P.	457	Siwalik conglomerate	Hilly	Deep	Dehra Dun	Br	Brown forest	0—28	35·5	47·6	9·6	1·6
									28—76	35·0	44·6	12·5	5·0
									76—128	79·0	3·7	2·5	2·5
									128—168	54·1	26·7	7·5	7·5

DIX B

TYPICAL SOILS

water deficiency; Aw=Per humid with moderate winter water deficiency; Br=Humid Cd - Sub humid with little or no water surplus; Cs - Sub humid with moderate winter with little or no water surplus; Ed - Arid with little or no water surplus).

Water holding capacity %	Moisture equivalent %	Nitrogen %	Organic matter %	pH	HCl Insoluble — Silica %	HCl soluble Fe$_2$O$_3$ %	HCl soluble Al$_2$O$_3$ %	HCl soluble CaO %	HCl soluble MgO %	HCl soluble K$_2$O %	HCl soluble P$_2$O$_5$ %	C.E.C. m. e. %	Exchangeable Ca m. e. %	Exchangeable Mg. m. e. %	Available P$_2$O$_5$ %	Available K$_2$O %
15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
47·8	19·4	0·125	3·03	5·2	69·6	3·8	3·4	0·45	0·12	·17	0·16	24·0	2·0	0·4	0·002	0·023
52·3	23·6	0·087	1·66	4·4	66·2	5·0	1·9	0·17	0·46	·23	0·19	33·1	1·0	0·6	0·002	0·020
70·5	36·2	0·070	1·45	4·5	70·4	10·5	21·3	0·22	0·54	·55	0·10	37·1	2·2	0·6	0·002	0·028
72·4	35·8	0·079	0·66	4·4	69·0	11·7	20·2	0·20	0·26	·39	0·15	50·3	0·6	0·4	0·002	0·023
61·7	35·7	0·06[illegible]	0·48	4·7	70·8	9·9	24·1	0·22	0·77	·16	0·07	56·5	0·4	10·2	0·002	0·020
62·0	34·2	0·048	0·55	4·5	71·6	11·5	18·1	0·28	0·40	·18	0·08	47·8	1·2	8·8	0·002	0·020
90·6	37·9	0·304	6·7	5·9	62·2	9·9	21·1	0·08	0·20	·30	0·18	27·7	8·4	1·0	0·0019	0·003
69·6	33·6	0·147	3·6	6·0	64·2	12·6	16·8	0·20	0·08	·43	0·12	21·0	4·4	1·8	0·0012	0·020
54·0	32·8	0·043	1·2	6·0	64·8	16·1	15·4	0·08	0·02	·29	0·13	19·9	2·6	1·2	0·0009	0·017
59·4	34·6	0·032	0·4	6·3	67·4	21·1	7·3	0·08	0·04	·20	0·04	15·4	2·0	1·0	0·0019	0·009
64·2	31·5	0·274	6·52	5·9	63·4	8·8	19·8	0·53	0·24	·39	0·18	47·8	6·2	1·0	0·002	0·065
60·1	25·6	0·154	4·19	5·6	70·4	9·1	16·8	0·25	0·46	·41	0·77	32·6	1·8	1·2	0·002	0·068
54·7	37·1	0·071	1·38	5·3	63·4	11·7	17·0	0·20	0·34	·36	0·14	38·2	3·0	0·8	0·002	0·048
49·4	29·3	0·062	1·03	5·2	67·6	7·8	7·3	0·20	0·22	·32	0·14	31·4	2·6	0·4	0·002	0·003
45·1	26·6	0·092	1·93	4·5	86·4	2·4	4·0	0·08	0·04	·11	0·19	14·8	0·6	0·4	0·003	0·014
46·4	28·9	0·052	0·86	4·5	80·0	4·8	7·6	0·14	0·14	·48	0·31	31·5	0·4	0·2	0·002	0·020
53·3	33·0	0·041	0·45	4·3	73·2	5·1	13·4	0·84	0·16	·32	0·23	35·9	0·2	0·4	0·002	0·017
44·3	24·7	0·022	0·17	4·6	83·0	2·7	11·5	0·14	0·10	·45	0·19	20·2	0·4	0·6	0·003	0·028
42·4	31·9	0·131	1·37	6·3	72·4	11·3	11·1	1·14	1·11	·17	0·01	30·3	20·62	0·6	0·002	0·069
43·5	32·0	0·068	1·90	6·5	72·[illegible]	8·6	15·8	0·83	1·23	·09	0·04	31·8	20·4	0·4	0·004	0·054
27·9	14·1	0·067	0·21	6·3	84·[illegible]	5·0	5·4	1·43	1·17	·09	0·03	18·2	11·6	0·4	0·003	0·104
38·0	27·5	0·046	2·07	5·5	54·5	18·1	16·3	0·43	0·20	·76	0·06	26·2	21·0	1·4	0·004	0·038
54·8	34·5	0·112	1·86	5·4	55·6	17·9	14·0	0·81	0·52	·15	0·05	32·4	23·2	2·0	0·003	0·003
44·1	27·1	0·099	0·38	5·3	59·7	13·3	12·5	0·93	0·48	·31	0·04	24·4	18·8	0·4	0·005	0·018
30·7	19·6	0·078	0·31	5·5	67·4	11·0	14·6	1·14	0·53	·38	0·08	17·8	14·6	0·4	0·003	0·035
54·12	40·12	0·137	3·10	5·7	66·1	8·1	16·1	0·35	0·35	·33	0·16	18·8	9·0	2·6	0·004	0·181
48·6	37·53	0·090	1·66	5·7	65·5	8·4	16·8	0·21	0·01	·70	0·10	15·8	8·0	1·6	0·002	0·197
46·0	31·04	0·057	1·10	5·6	67·4	8·6	16·2	0·13	0·17	·29	0·09	15·8	0·6	1·8	0·002	0·045
48·9	34·34	0·045	0·83	5·8	69·3	8·5	16·3	0·17	0·03	·24	0·07	12·8	8·8	1·6	0·003	0·056
31·1	27·4	0·08	2·21	6·2	87·4	1·2	4·6	0·23	0·12	·62	0·11	19·5	3·8	Tr.	0·0018	0·011
28·4	21·3	0·05	1·14	6·4	89·5	2·0	3·3	0·23	0·24	[illegible]	0·07	24·6	8·0	0·2	0·0014	0·008
28·4	16·2	0·03	0·55	6·6	90·0	1·8	1·9	0·25	0·10	·31	0·06	18·2	5·0	Tr.	0·0023	0·006
28·6	19·5	0·04	0·52	8·0	90·5	1·9	2·4	0·22	0·10	·75	0·06	25·61	1·8	1·4	0·0027	0·006

APPENDIX

1	2	3	4	5	6	7	8	9	10	11	12	13	14
Moist *Bhabar* Sal. (3C/C2h)	Lachhiwala Dehra Dun Division, U.P.	610	Siwalik conglomerate	Gentle Southern slope	Deep	Dehra Dun	Br	Alluvial	0—15 15—33 33—84 84—165	5·75 10·5 5·9 5·9	25·3 34·2 37·7 32·9	56·6 39·3 33·6 38·8	10·5 10·9 15·0 13·4
Moist plains sal (eastern heavy alluvium). (3C/C2d(i))	Dudhai, Gorakhpur Division, U.P.	152	Alluvium	Flat	Shallow	Gorakhpur	Cw	Alluvial	0—20 20—48 48—107 107—183	4·9 5·4 4·6 5·0	40·4 39·3 24·7 34·5	27·5 35·0 27·5 22·5	20·0 12·0 27·5 32·5
Moist plains sal (western light alluvium). (3C/C2d(ii))	Chaltua, South Kheri Division, U.P.	..	Alluvium	Flat	..	Kheri	Cw	Alluvial	0—10 10—30 30—129 129—175 175—198	3·8 3·6 3·5 3·4 3·0	30·9 36·7 40·1 38·8 52·3	35·0 32·5 27·5 35·0 22·5	22·5 25·0 25·0 17·5 15·0
Moist Peninsular sal. (3C/C2e)	Korar Range, Kanker Division, M.P.	..	Laterite; Granite-gneiss.	..	..	Raipur	Cw	Laterite	0—15 15—30 30—61 61—122 122—184	33·8 43·3 35·0 46·1 62·5	23·9 12·0 23·4 13·0 13·8	17·5 17·5 5·0 12·5 5·0	20·0 27·5 37·5 27·5 17·5
Littoral forest. (4A/L1) (Casuarina plantation)	Gollapallen, North Nellore Division, Andhra Pradesh.	3	Coastal alluvium.	Flat low land	2 (Fluctuating)	Madras	Dd	Coastal sand	0—5 5—23 23—51 51—91 91—122	83·0 85·7 76·7 57·4 53·0	9·3 7·1 7·0 8·6 5·4	2·5 2·5 10·0 2·5 5·0	2·5 2·5 5·0 30·0 35·0
Littoral forest. (4A/L1) (Casuarina plantation)	Karwar Range, W. D. Kanara Division, Mysore.	3	Coastal alluvium	Flat low land	122	Karwar	Aw	Coastal alluvium	0—13 13—53 53—61 61—76 76—86 86—152 152—183	72·1 85·6 84·8 88·9 85·3 89·3 88·3	4·1 4·4 4·6 2·3 3·4 1·2 1·4	10 0 2·5 2·5 1·25 7·5 2·5 2·5	7·5 5·0 5·0 6·25 2·5 5·0 5·0
Very dry teak. (5A/C1a)	Banswara Division, Rajasthan.	..	..	..	..	Kotah Indore	Bw	..	0—30 30—48 48—76 76—107	26·3 25·2 27·6 34·6	31·2 31·4 31·3 30·0	37·5 17·5 15·0 12·5	2·5 25·0 20·0 22·5
Dry teak. (5A/C1b)	756, Khanapur, Nirmal Division. Andhra Pradesh.	287	Granite with quartz. intrusions.	High terrain undulating.	8	Kurnool	Dd	Red	0—23 23—66 66—137	56·6 64·4 57·6	22·9 12·0 12·4	2·5 2·5 10·0	17·5 12·5 15·0
Southern dry mixed deciduous (degraded). (5A/C3(DS1))	3, Bavangaja, Khargone Division, Madhya Pradesh.	366	Trap.	Hill top	12	Indore	Cw	Brown forest	0—10 10—30 30—69 69—91 91—183	19·2 20·5 8·5 12·7 30·8	28·1 21·1 12·0 10·0 19·8	30·0 20·0 30·0 25·0 15·0	7·5 7·5 20·0 17·5 10·0
Southern dry mixed deciduous (degraded). (5A/C3(DS1))	Deolgaon, Poona Division, Maharashtra.	..	Trap.	Plateau	12	Poona	Dd	Black (highly calcareous)	0—91 91—183	3·0 31·4	10·3 24·7	27·5 20·0	35·0 7·5

B—(*contd.*)

15	16	17	18	19	20	21	22	33	24	25	26	27	28	29	30	31
40·7	35·7	0·14	2·86	6·2	81·7	1·5	10·7	0·14	0·10	·49	0·07	26·6	11·2	1·0	0·0036	0·028
39·1	34·7	0·05	1·0	6·1	81·7	1·5	13·2	0·22	0·12	·68	0·15	23·4	6·1	Tr.	0·0018	0·029
37·0	32·5	0·04	0·45	5·9	82·1	1·3	12·2	0·21	0·20	·77	0·07	27·5	5·0	0·6	0·0018	0·026
35·7	32·6	0·05	0·62	5·8	87·4	1·6	5·1	0·21	0·10	·79	0·07	27·2	6·0	Tr.	0·0009	0·026
46·4	31·1	0·10	2·1	6·3	83·3	4·6	6·7	0·25	0·30	·94	0·11	16·5	6·8	0·2	0·0045	0·010
41·7	31·1	0·07	1·3	5·8	80·5	6·4	8·5	0·22	0·68	1·31	0·09	13·8	5·2	0·4	0·0032	0·010
38·0	31·2	0·07	1·2	5·9	79·5	4·4	10·2	0·20	0·46	1·47	0·10	17·0	5·6	0·8	0·0034	0·003
36·5	32·1	0·04	0·4	6·1	77·2	5·9	10·4	0·25	0·24	1·16	0·11	15·4	8·0	0·2	0·0025	0·023
..	..	0·16	2·60	..	82·7	9·82		0·30	1·18	1·18	0·03	12·16	7·0	2·8	0·001	0·035
40·4	27·9	0·09	1·66	7·2	83·7	10·00		0·28	1·19	1·22	0·07	12·48	5·2	2·0	0·012	0·053
36·9	26·5	0·04	0·45	7·0	82·1	12·00		0·20	1·20	1·24	0·02	8·66	2·8	1·2	0·008	0·018
41·4	31·2	0·03	0·21	7·0	81·7	12·42		0·22	1·40	1·21	0·03	8·00	3·2	1·6	0·012	0·012
42·8	32·5	0·03	1·03	7·1	83·0	12·27		0·25	1·65	1·20	0·03	6·83	3·0	1·6	0·012	0·017
37·1	24·3	0·137	3·4	5·4	70·9	3·4	15·5	0·27	0·55	0·64	0·04	32·2	6·0	3·0	0·0007	0·037
32·7	23·6	0·067	1·8	5·6	77·8	6·9	11·7	0·08	0·21	0·24	0·04	28·0	4·6	1·6	Tr.	0·053
30·9	20·7	0·005	1·2	5·3	83·0	4·2	8·4	0·08	0·17	0·41	0·05	21·4	3·0	0·8	0·0005	0·043
33·6	18·9	0·038	0·9	5·6	78·4	6·9	14·1	0·06	0·26	0·64	0·04	18·5	2·8	1·0	Tr.	0·045
27·9	12·3	0·009	0·5	5·7	71·5	3·9	8·1	0·11	0·23	0·31	0·04	14·3	0·8	0·4	Tr.	0·043
26·1	17·9	0·071	2·24	6·6	94·4	2·9	1·9	0·14	0·08	0·17	0·01	7·6	2·0	0·8	0·0015	0·011
23·8	15·5	0·020	0·86	6·3	96·4	2·7	0·3	0·11	0·08	0·30	0·01	4·8	1·6	0·8	0·0014	0·008
28·8	9·7	0·034	0·34	6·1	94·5	1·5	2·6	0·14	0·16	0·37	0·02	6·8	2·5	0·6	0·0017	0·005
52·2	25·7	0·032	0·10	7·0	88·2	2·5	5·7	0·20	0·20	0·11	0·01	10·8	2·9	1·4	0·0010	0·014
55·7	28·8	0·014	2·83	5·6	86·6	2·3	6·1	0·25	0·36	0·26	0·01	25·8	3·9	1·8	0·0010	0·017
20·0	7·0	0·045	4·21	5·4	91·8	2·6	4·7	0·14	0·06	0·40	0·02	12·8	0·6	0·6	0·0015	0·034
25·0	7·0	0·009	0·70	6·2	93·1	2·2	3·8	0·08	0·04	0·37	0·02	9·8	0·4	0·4	0·0010	0·034
24·7	6·0	0·010	0·60	5·1	86·7	4·3	7·6	0·14	0·06	0·46	0·02	7·9	0·6	0·2	0·001	0·024
25·6	8·7	0·009	0·60	5·4	94·3	2·9	2·1	0·20	0·06	0·39	0·02	8·1	0·6	0·2	0·0000	0·028
24·5	12·1	0·005	0·30	7·1	87·4	4·6	6·6	0·08	0·08	0·28	0·02	8·0	0·4	0·2	0·0003	0·031
26·0	3·9	0·004	0·30	6·9	94·7	2·6	1·5	0·11	0·06	0·41	0·02	8·2	0·6	0·2	0·0006	0·050
26·0	9·7	0·004	0·24	7·0	90·[illegible]	3·4	3·9	0·17	0·04	0·29	0·02	7·8	0·6	0·2	0·0004	0·041
38·4	26·3	0·076	1·83	5·7	74·[illegible]	6·6	12·6	0·38	0·29	1·75	0·05	18·6	12·0	2·2	0·003	0·0[illegible]1
39·8	27·5	0·056	1·00	5·5	74·[illegible]	5·8	15·0	0·29	0·64	1·59	0·03	17·0	11·0	0·2	0·005	0·0[illegible]8
[illegible]·0	25·0	0·049	1·38	5·5	78·[illegible]	6·8	11·3	0·25	0·33	1·42	0·3	13·3	9·6	2·0	0·007	0·012
35·2	30·8	0·031	0·86	5·5	77·1	5·9	9·7	0·28	0·47	1·11	0·04	15·2	8·8	0·2	0·006	0·039
29·0	12·3	0·056	1·00	6·1	90·6	2·4	2·6	0·28	0·11	0·54	0·27	11·0	6·8	0·8	0·001	0·010
32·6	18·0	0·041	0·24	5·0	84·5	4·0	7·1	0·34	0·23	0·38	0·21	19·8	11·0	0·2	0·002	0·012
31·8	20·8	0·013	0·76	5·0	80·2	3·6	5·2	0·46	0·31	0·45	0·19	16·9	12·8	2·0	0·005	0·006
55·7	29·1	0·07	1·5	6·8	67·2	10·4	12·2	2·0	0·34	0·14	0·05	53·6	42·2	5·0	0·0049	0·043
56·8	40·9	0·05	1·3	6·9	64·9	10·7	12·8	1·8	0·14	0·21	0·06	57·4	37·0	0·8	0·0000	0·031
74·9	49·1	0·07	1·8	7·1	59·7	13·1	16·9	1·3	0·46	0·36	0·04	56·4	40·4	3·2	0·0025	0·011
80·8	39·9	0·01	0·7	7·3	58·9	11·1	14·9	1·0	0·36	0·27	0·02	66·2	88·4	3·4	0·0010	0·017
70·3	34·0	0·05	2·2	7·4	63·9	6·4	17·4	1·5	0·46	0·44	0·06	72·2	66·8	2·6	0·0049	0·006
86·9	46·3	0·07	1·5	8·3	58·9	5·7	18·8	8·32	0·12	0·31	0·05	67·8	40·4	2·2	0·00	0·00
60·3	35·4	0·02	1·7	8·6	66·1	9·6	11·3	0·39	0·14	0·[illegible]	0·06	40·5	14·4	1·4	0·152	0·00

APPENDIX

1	2	3	4	5	6	7	8	9	10	11	12	13	14
Southern dry mixed deciduous (degraded) (5A/C3(DS1)	Sahibnagar, Hyderabad Division, Andhra Pradesh.	518	Granitic gneiss	Plateau undulating	21	Kurnool, Warrangal	Dd	Red (bouldry)	0—13 13—127 127—183	64·0 46·6 54·7	24·0 17·9 22·9	2·5 2·5 7·5	7·5 25.0 7·5
Southern dry mixed deciduous. (5A/C3) (Casuarina plantation)	Marsendra, Bangalore Division, Mysore.	792	Granite	Plateau Flat upland	20	Bangalore	Dd	Red	0—8 8—56 56—102 102—165	39·5 28·3 25·7 30·7	14·0 15·2 14·5 12·0	25·0 5·0 10·0 15·0	20·0 50·0 47·5 40·0
Southern dry mixed deciduous (degraded). (5A/C3(DS1)	Vandalur, Saidapet Division, Madras	..	Gneiss	Plateau	Shallow	Madras	Cs	Red (calcareous below 10 cm.)	0—10 10—20 20—51 51 below.	64·4 51·8 30·1 32·6	25·6 37·8 39·0 21·6	5·0 2·5 10·0 7·5	5·0 7·5 17·5 30·0
Dry plains sal. (5B/C1b)	Motipur, Bahraich Division, Uttar Pradesh.	..	Alluvium	Flat	..	Gorakhpur Kheri	Cw	Alluvial	0—23 23—61 61—122 122—183	20·0 19·0 18·1 25·2	46·2 44·9 42·3 42·4	15·0 12·5 17·5 10·0	15·0 20·0 20·0 20·0
Dry peninsular sal. (5B/C1c)	Rambadevi Block Deogarh Division, Orissa.	305	Granite, schist, quartzite	Plateau undulating	8	Angul Sambalpur	Cw	Black (stiff calcareous).	0—15 15—58 58—92 92—122	6·2 8·7 19·3 48·3	16·7 14·7 13·0 13·4	35·0 32·5 32·5 12·5	30·0 27·5 27·5 12·5
Southern thorn (degraded) (5A/C1(DS1)	Anaboor, Chitradurg Division, Mysore.	701	Gneiss	Plateau	21	Bellary	Ed	Red	0—46 46—76 76—168	31·7 23·6 37·4	30·2 23·8 30·6	17·5 17·5 10·0	15·0 27·5 10.0
Desert thorn (degraded) (6B/C1(DS1)	Nimdi-dalot, Hissar Division, Punjab.	..	Aeolian sand	Alluvial plain	30	Delhi	Ed	Desert	0—7 7—23 23—183	8·8 8·6 9·3	83·5 80·5 81·2	2·5 2·5 2·5	5·0 7·5 5·0
Desert thorn (6B/C1)	Guda-Andla, Jodhpur Division, Rajasthan.	219	Alluvium	Valley bottom	6	Jodhpur	Dd	Desert (calcareous below 60 cm.)	0—7 7—61 61—91 91—130 130—154 154—183	31·6 37·3 44·5 38·6 47·1 17·0	31.9 22·6 15·6 14·2 13·6 7·20	17·5 12·5 5·0 2·5 5·0 2·5	17·5 22·5 15·0 15·0 15·0 17·5
Desert thorn (degraded) (6B/C1(DS2)	Kailana, Jodhpur Division, Rajasthan.	305	Sandstone	Hilly, undulating	22	Jodhpur	Ed	Desert (calcareous)	0—53 53—below.	24·9 9·2	56·3 65·9	5·0 2·5	10·0 12·5
Ravine thorn (6B/C2)	Chaugan, Vrajbhumi Division, Uttar Pradesh.	169	Alluvium	Alluvial plain	20	Agra	Dd	Alluvial (calcareous kanker pan at 60-140 cm.)	0—15 15—61 61—130 130—183	0·7 0·2 0·5 0·6	62·7 65·7 33·3 70·1	12·5 10·0 20·0 5·0	10·0 10·0 20·0 5·0

B—(*contd.*)

15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
28·9 50·0 47·6	6·7 17·9 14·6	0·03 0·02 0·02	0·9 0·9 0·2	5·6 5·3 6·0	84·0 82·6 80·2	1·3 2·6 4·0	0·9 3·3 0·6	0·17 0·28 0·79	0·08 0·02 0·06	0·16 0·31 0·42	0·04 0·04 0·06	12·4 13·7 15·5	7·2 11·6 13·6	0·4 0·4 0·6	0·0074 0·0074 0·0099	0·057 0·022 0·014
30·2 37·5 40·8 40·5	18·7 19·9 22·2 21·9	0·038 0·036 0·032 0·013	1·35 0·93 0·69 0·28	4·9 5·1 6·2 7·2	85·2 75·8 81·5 72·0	1·1 2·6 2·7 2·9	8·9 15·3 9·3 17·3	0·22 0·17 0·11 0·22	0·02 0·06 0·02 0·02	0·17 0·29 0·36 0·34	0·06 0·03 0·01 0·02	13·6 23·5 23·0 21·4	0·8 1·0 1·2 1·0	0·4 0·4 0·6 0·6	0·0001 0·0001 0·0012 0·0017	0·025 0·024 0·047 0·024
24·6 30·2 37·4 93·2	6·9 18·9 26·0 57·1	0·02 0·01 0·02 0·02	0·9 0·07 0·07 0·06	5·5 7·5 9·0 9·3	85·1 84·0 77·3 67·4	8·3 10·2 13·9 8·6	2·6 1·7 3·5 11·4	0·14 0·17 0·31 0·45	0·16 0·07 0·10 0·10	0·04 0·12 0·12 0·07	0·06 0·08 0·15 0·12	13·9 15·5 21·0 42·5	7·0 4·4 2·2 7·4	0·2 0·8 0·6 1·0	0·005 0·011 0·007 0·016	0·019 0·003 0·003 0·006
30·7 27·6 29·5 28·9	20·9 19·6 19·8 18·1	0·10 0·05 0·01 0·05	2·00 0·03 0·48 0·62	7·0 7·3 7·0 7·0	88·7 87·7 85·7 86·4	6·84 8·08 9·71 8·90		0·21 0·17 0·14 0·16	0·37 0·38 0·78 0·61	0·55 0·61 0·71 0·92	0·08 0·14 0·02 0·07	10·08 10·08 9·12 9·12	5·4 3·0 2·8 3·2	0·4 0·8 0·4 0·4	0·012 0·010 0·012 0·016	0·070 0·089 0·027 0·013
68·0 75·7 69·2 54·5	42·1 43·5 41·1 30·2	0·03 0·03 0·01 0·01	0·9 0·6 0·6 0·3	7·4 7·7 7·8 7·5	75·7 71·5 54·5 75·9	8·6 9·1 9·6 10·6	6·2 8·9 14·5 4·8	1·23 2·52 1·63 1·96	0·08 0·10 0·08 0·08	0·18 0·22 0·19 0·12	0·05 0·04 0·06 0·04	40·1 40·4 38·2 34·0	30·0 29·2 25·8 18·0	2·8 2·6 3·0 2·6	0·0021 0·0021 0·0009 0·0028	0·065 0·084 0·084 0·084
37·9 44·5 34·6	22·4 15·1 21·2	0·04 0·06 0·01	1·37 1·5 0·52	6·5 6·9 7·2	82·6 78·8 82·5	3·0 5·4 6·7	10·6 12·3 5·9	0·20 0·25 0·42	0·20 0·12 0·10	0·27 0·24 0·19	0·05 0·05 0·03	31·9 22·2 16·2	7·6 10·6 12·8	0·6 1·0 1·2	0·0111 0·0124 0·0099	0·011 0·009 0·009
28·8 31·5 29·9	17·9 9·8 9·0	0·02 0·02 0·01	0·2 0·2 0·2	6·9 6·8 6·8	94·7 92·9 94·1	1·8 2·1 1·4	2·3 3·3 3·6	0·62 0·67 0·48	0·04 0·02 0·02	0·35 0·30 0·29	0·08 0·07 0·06	13·4 10·3 9·0	5·0 5·6 4·4	0·2 0·4 0·2	0·0022 0·0004 0·0009	0·017 0·006 0·011
40·5 45·5 37·1 48·5 48·9 49·2	24·1 24·8 15·1 19·8 22·6 24·5	0·07 0·12 0·03 0·05 0·02 0·02	1·2 0·5 0·5 0·5 0·6 0·2	6·7 7·2 7·7 7·8 6·7 8·6	87·6 84·8 75·5 69·8 65·1 46·3	3·8 4·8 3·4 4·5 7·2 2·4	4·5 6·1 6·8 9·4 10·2 22·3	0·62 0·89 8·79 10·0 9·16 22·9	0·10 0·12 0·26 0·24 0·28 0·22	1·13 1·28 0·98 1·06 1·04 0·63	0·03 0·04 0·06 0·05 0·06 0·06	31·84 41·3 12·7 12·6 9·5 7·9	9·0 17·0 8·6 7·6 4·6 3·8	0·4 0·6 0·6 0·8 0·6 0·4	0·0009 0·0019 0·0023 0·0030 0·0031 0·0034	0·036 0·031 0·034 0·017 0·034 0·025
30·4 36·8	15·3 18·9	0·02 0·02	0·24 0·14	8·0 8·0	85·2 77·5	1·4 0·8	5·9 13·2	4·79 6·33	0·14 0·08	0·56 0·36	0·03 0·06	7·3 7·0	4·6 4·2	0·4 0·6	0·0031 0·0029	0·014 0·011
39·7 43·6 52·1 34·1	23·5 16·3 30·8 23·5	0·05 0·02 0·03 0·01	0·4 0·17 0·14 0·07	7·8 8·1 8·3 8·5	84·7 80·7 72·4 84·5	3·5 3·2 2·7 2·6	5·5 11·9 18·9 10·7	4·5 2·2 5·0 3·8	0·06 0·02 0·02 0·04	0·64 1·62 1·65 0·85	0·07 0·08 0·09 0·06	16·3 15·4 14·2 12·1	7·2 7·2 8·0 3·8	0·6 0·6 0·8 0·6	0·0023 0·0015 0·0019 0·0038	0·014 0·014 0·011 0·008

APPENDIX

1	2	3	4	5	6	7	8	9	10	11	12	13	14
Ravine thorn (6B/C2)	Nurabad, Gwalior Division, Madhya Pradesh.	..	Sand stone shale	Ravine	8	Agra Etawah	Cd	Saline calcareous below 75 cm. Kankar pan at 75—120 cm.	0—18 18—76 76—122 122—183	9·7 2·5 1·0 1·0	65·4 51·0 48·0 48·6	7·5 20·0 12·5 10·0	15·0 20·0 20·0 17·5
Rann saline thorn. (6/E3)	Radhanpur Range, Banaskantha Division, Gujarat.	..	Alluvium	Alluvial plain	4 (undulating)	Bhuj	Ed	Saline/alkali (calcareous)	0—13 13—46 46—76 76—168 168—183	0·25 0·20 6·6 0·1 0·35	68·6 18·0 80·6 46·3 73·6	17·5 32·5 2·5 20·0 5·0	5·0 25·0 2·5 10·0 2·5
Himalayan chir pine (9/C1b)	Kasol Khobas Comptt. No. 2, Kulu Forest Division, Punjab.	1365	Quartzite; Mica schist	Hilly	..	Simla	Br	Immature	0—4 4—13 13—73 73—102 102—154 154—below	11·6 21·5 24·1 38·7 39·7 29·5	21·2 37·5 42·3 47·2 45·6 39·6	28·8 27·6 25·5 9·2 10·3 22·0	4·5 6·0 5·2 3·6 3·2 5·3
Ban oak (*Q.* ***incana***) (12/C1a)	Chaubattia, Kumaon Hills. Uttar Pradesh.	1859	Garnetiferous biotite schist & granite gneiss	Hilly	..	Ranikhet	Ar	Brown forest	0—30 30—51 51—91	1·10 0·8 1·0	22·5 28·6 31·6	39·1 42·3 37·0	23·1 23·4 27·1
Moru oak (*Q. dilatata*) (12/C1b)	Lurli 1, Chakrata Division, Uttar Pradesh.	2209	Shale	Hilly	..	Chakrata	Ar	Brown forest	0—16 16—60 60—102 102—183	2·3 11·4 0·8 0·8	25·3 26·0 20·4 24·8	45·0 30·0 47·6 20·0	22·5 30·0 32·5 47·5
Moist deodar ((*Cedrus*) 12/C1c)	Borsu 1/31 Comptt. Kulu Forest Division, Punjab.	2406	Mica schist	Hilly	..	Simla	Br	Podsol	0—10 10—36 36—44 44—67 67—below	5·4 11·4 5·9 4·9 7·1	19·6 25·3 17·7 17·5 24·9	45·6 47·9 50·4 52·1 53·2	8·3 7·5 8·7 13·3 6·8
Western mixed coniferous (12/C1e)	Compt. 3. Veshav Block, Haripur Range, Kashmir.	2590	Karewa deposits (lacustrine)	Undulating	..	Srinagar	Cw	Brown earth	0—25 25—43 43—53 53—91 91—137	0·1 0·4 0·7 0·9 1·0	19·3 25·5 24·3 28·4 24·3	52·3 53·0 52·6 47·6 51·4	15·5 15·9 17·8 14·6 14·4
West Himalayan upper oak-fir (12/C2b)	Deoban 9A, Chakrata Division. Uttar Pradesh.	2819	Lime stone, schist, quartzite.	Hilly upper slope	..	Chakrata	Ar	Podsolic	0—14 14—30 30—68 68—84 84—193	1·0 0·6 0·3 0·6 0·8	21·6 25·5 34·1 24·8 19·5	55·4 47·5 33·2 41·5 36·9	18·5 21·1 23·0 28·5 39·6
Low level blue pine (12/2S1)	Comptt. 61, Rainawari Range, Kashmir.	1839	Karewa deposits (lacustrine)	Undulating	..	Srinagar	Cw	Immature podsol	0—9 9—41 41—88 88—below	1·7 5·5 7·8 0·6	16·3 23·2 26·7 26·0	44·8 41·8 41·0 53·2	18·0 22·9 17·8 14·8

B—(*concld.*)

15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
41·6	16·9	0·05	0·31	6·9	90·0	4·3	7·1	0·3	0·36	0·38	0·05	21·9	8·4	0·6	0·0002	0·028
51·5	23·6	0·04	0·24	7·4	83·0	3·6	6·6	0·8	0·89	0·35	0·19	40·6	21·8	1·2	0·0001	0·034
52·7	25·6	0·03	0·2	8·3	75·0	4·2	9·5	6·4	0·54	0·47	0·15	15·0	11·4	1·0	0·0001	0·020
49·9	22·3	0·03	0·2	7·9	88·0	3·5	7·4	5·7	0·42	0·26	0·20	14·2	9·8	1·0	0·0004	0·016
52·9	42·4	0·03	0·6	7·9	76·5	4·2	9·91	2·65	0·01	1·06	0·15	23·9	7·0	1·0	0·0000	0·003
59·1	34·3	0·03	0·3	7·9	73·4	4·3	10·80	0·84	0·02	0·26	0·16	19·4	8·0	0·6	0·0049	0·028
51·1	19·7	0·01	0·6	8·1	87·7	1·8	6·54	4·58	0·01	1·06	0·09	8·7	3·0	0·4	0·0074	0·020
49·4	32·0	0·04	0·4	7·5	76·4	3·8	11·89	1·36	0·02	0·48	0·10	13·3	8·2	1·0	0·0000	0·017
36·1	14·0	0·01	0·3	7·7	87·3	1·6	7·27	3·36	0·08	1·24	0·11	7·9	4·8	1·0	0·0037	0·026
..	..	..	27·2	6·3	42·2	17·0	2·4	..	..	..	..	42·3	34·2	0·6	..	..
..	..	..	6·4	6·1	46·3	21·2	6·2	..	..	..	..	23·7	10·7	0·7	..	..
..	..	..	2·2	6·3	42·2	19·4	9·8	..	..	..	..	17·3	5·3	0·6	..	..
..	..	..	1·1	6·7	45·5	20·2	14·0	..	..	..	..	15·4	3·9	0·5	..	..
..	..	..	0·6	5·7	49·3	17·6	13·8	..	..	..	..	13·3	3·9	0·3	..	..
..	..	..	1·58	6·3	48·0	17·8	13·4	..	..	..	..	18·6	5·1	0·6	..	..
..	..	..	8·2	6·2	69·2	5·2	8·8	0·32	0·69	..	..	..	..	..	..	..
..	..	..	1·2	5·8	76·9	5·6	9·1	0·05	1·00	..	..	..	..	..	..	..
.	..	..	0·4	6·4	78·1	5·5	8·5	0·70	1·23	..	..	..	..	..	..	..
88·3	61·2	0·308	6·4	5·8	58·7	5·11	21·45	0·73	0·02	0·74	0·07	28·9	4·6	0·4	0·005	0·037
66·7	40·1	0·069	1·5	5·5	85·5	6·07	2·54	0·76	0·04	0·73	0·07	26·3	2·6	0·2	0·014	0·031
50·9	34·5	0·037	0·7	5·2	74·2	6·23	14·09	0·31	0·02	0·67	0·06	29·4	3·0	0·4	0·008	0·065
48·6	32·9	0·030	0·6	4·0	77·3	4·47	13·15	0·42	0·02	0·52	0·09	33·8	2·8	0·2	0·011	0·170
..	..	..	16·0	6·4	51·0	16·6	19·2	..	..	..	..	46·2	37·8	1·0	..	..
..	..	.	5·8	6·0	45·0	13·9	14·6	..	..	..	..	25·7	12·3	0·7	..	..
..	..	..	11·7	6·5	43·7	20·4	16·9	..	..	..	..	40·2	26·6	0·7	..	..
..	..	..	8·0	6·3	42·7	19·4	13·9	..	..	..	..	33·3	19·0	0·7	..	..
..	..	..	4·0	6·1	43·8	20·0	12·0	..	..	..	..	26·9	13·0	0·6	..	..
..	..	..	..	5·8	54·4	15·7	21·6	..	..	..	..	34·2	26·8	0·6	..	..
..	..	..	..	5·4	53·1	15·6	24·6	..	..	..	..	27·2	11·5	0·3	..	..
..	..	..	..	5·7	51·4	16·3	32·8	..	..	..	..	21·4	13·3	1·8	..	..
..	..	..	..	5·8	51·4	16·0	25·6	..	..	..	..	21·8	14·5	2·5	..	..
..	..	..	..	5·9	50·4	16·8	26·0	..	..	..	..	20·0	15·8	2·7	..	..
76·7	46·5	0·307	4·9	5·5	69·4	4·95	7·89	0·62	0·22	0·53	0·16	26·4	16·2	0·8	0·003	0·025
69·0	52·4	0·150	3·8	5·2	72·2	4·95	10·05	0·11	0·22	0·47	0·13	15·7	5·4	0·4	0·002	0·021
53·0	38·5	0·034	0·9	5·1	74·0	5·27	10·61	0·31	0·20	0·83	0·09	15·0	3·8	0·6	0·002	0·025
61·8	34·5	0·101	1·0	5·4	74·6	6·71	6·89	0·34	0·30	0·99	0·15	17·7	6·2	0·8	0·003	0·025
63·6	34·0	0·049	0·7	6·1	69·6	5·89	14·01	0·65	0·56	1·05	0·18	25·4	20·4	1·0	0·003	0·031
..	.	..	..	6·7	51·2	15·8	23·7	..	..	..	..	48·35	37·6	1·9	..	..
..	.	..	..	6·3	51·6	17·3	26·4	..	..	..	..	28·0	20·3	1·3	..	..
..	..	..	..	6·2	50·2	16·0	22·4	..	..	..	..	29·80	20·8	0·9	..	..
..	..	..	..	6·5	50·0	17·6	26·1	..	..	..	..	27·90	23·9	0·9	..	..

APPENDIX C (i)

CONCORDANCE TABLE

Relating the Forest Types recognized in the Revised Survey with those of the Preliminary Survey.

REVISED SURVEY		PRELIMINARY SURVEY	
Type No.	Forest Type	Type No.	Forest Type
1	2	3	4
	MOIST TROPICAL FORESTS		**MOIST TROPICAL FORESTS**
	GROUP 1—TROPICAL WET EVERGREEN FORESTS		TROPICAL WET EVERGREEN FORESTS
	Subgroup 1A—Southern tropical wet evergreen forests		**Group 1a—Southern tropical wet evergreen forests**
1A/C1	(Giant evergreen forest)	1a/C1	Evergreen Dipterocarp forest
1A/C2	Andamans tropical evergreen forest	1a/C2	Eastern tropical evergreen forest
1A/C3	Southern hilltop tropical evergreen forest	1a/C3	Low tropical evergreen forest
1A/C4	West Coast tropical evergreen forest	1a/C4	Western tropical evergreen forest
	Subgroup 1B—Northern tropical wet evergreen forests		**Group 1b—Northern tropical wet evergreen forests**
1B/C1	Assam Valley tropical wet evergreen forest (*Dipterocarpus*)	1b/C2	Upper Assam tropical evergreen forest
1B/C2	Upper Assam Valley tropical evergreen forest		..
1B/C2a	*Kayea forest*		..
1B/C2b	*Mesua forest*		..
1B/C3	Cachar tropical evergreen forest	1b/C3	Cachar tropical evergreen forest
1/E1	Cane brakes	M.Tr/E8	Cane brake
1/E2	Wet bamboo brakes	M.Tr/E9	Southern wet bamboo brake
1/2S1	Pioneer Euphorbiaceous scrub		..
	GROUP 2—TROPICAL SEMI-EVERGREEN FORESTS		TROPICAL SEMI-EVERGREEN FORESTS
	Subgroup 2A—Southern tropical semi-evergreen forests		**Group 2a—Southern tropical semi-evergreen forests**
2A/C1	Andamans semi-evergreen forest	M.Tr/1S/8(a)	Southern riverain semi-evergreen forest

APPENDIX C (i)—*contd.*

1	2	3	4
	Subgroup 2A—Southern tropical semi-evergreen forests—*contd.*		**Group 2a Southern tropical semi-evergreen forests**—*contd.*
2A/C2	West Coast semi-evergreen forest	2a/C2	West Coast semi-evergreen forest
2A/C3	Tirunelveli semi-evergreen forest		..
2A/2S1	West Coast secondary evergreen Dipterocarp forest	M.Tr/2S/1	Secondary evergreen Dipterocarp forest
	Subgroup 2B—Northern tropical semi-evergreen forests		**Group 2b—Northern tropical semi-evergreen forests**
2B/C1	Assam Valley semi-evergreen forests	2b/C1	Upper Assam semi-evergreen forest
2B/C1a	Assam alluvial plains semi-evergreen forest		
2B/C1b	Eastern submontane semi-evergreen forest		
2B/C1/1S1	Sub-Himalayan light alluvial semi-evergreen forest	2b/C4	Sub-Himalayan semi-evergreen forest
2B/C1/2S1	(Pioneer Euphorbiaceous scrub)		..
2B/C1/2S2	Eastern alluvial secondary semi-evergreen forest	M.Tr/2S/2b	Northern secondary semi-evergreen forest
2B/C1/2S3	Sub-Himalayan wet mixed forests	M.Tr/2S/4	East sub-Himalayan wet mixed forest
2B/C2	Cachar semi-evergreen forest	2b/C2	Cachar semi-evergreen forest
2B/C3	Orissa semi-evergreen forest	2b/C5	Orissa semi-evergreen forest
2/E1	(Cane brakes)	M.Tr/E8	Cane brake
2/E2	(Wet bamboo brakes)	M.Tr./E9	Southern wet bamboo brake
2/E3	Moist bamboo brakes	M.Tr/E10(a)	Southern moist bamboo brake
2/E4	Lateritic semi-evergreen forest	M.Tr/E2	Western laterite (*Xylia*) semi-evergreen forest
2/2S1	Secondary moist bamboo brakes	M.Tr/E10(b) M.Tr/2S/8	Northern moist bamboo brake Secondary bamboo brake
	GROUP 3—TROPICAL MOIST DECIDUOUS FORESTS		TROPICAL MOIST DECIDUOUS FORESTS
	Subgroup 3A—Andamans moist deciduous forest		..
3A/C1	Andamans moist deciduous forest	M.Tr/E3	Andamans moist deciduous forest
3A/2S1	Andamans secondary moist deciduous forest		..

APPENDIX C (i)—*contd.*

1	2	3	4
	Subgroup 3B—South Indian moist deciduous forests		**Group 3a—Southern tropical moist deciduous forests**
3B/C1	Moist teak-bearing forests	3a/C1	South Indian moist deciduous forest
3B/C1a	Very moist teak forest		
3B/C1b	Moist teak forest		
3B/C1c	Slightly moist teak forest		
3B/C2	Southern moist mixed deciduous forest		
3B/2S1	Southern secondary moist mixed deciduous forest	M.Tr/2S/6(a)	Southern secondary moist deciduous forest
	Subgroup 3C—North Indian moist deciduous forests		**Group 3b—Northern tropical moist deciduous forests**
3C/C1	Very moist sal-bearing forests	3b/C2	Wet hill sal
3C/C1a	Very moist hill sal		
3C/C1b	Very moist *bhabar* sal		
3C/C1c	Very moist *tarai* sal	M/Tr/2S/5(a)	Wet plains sal
3C/C1d	Very moist peninsular (coastal) sal	M.Tr/2S/5(b)	Coastal sal
3C/C2	Moist sal bearing forests	3b/C1	Moist sal
3C/C2a	Moist siwalik sal		
3C/C2b	Moist *bhabar* sal		
3C/C2c	Moist *tarai* sal		
3C/C2d	Moist plains sal		
3C/C2e	Moist peninsular sal		
3C/C2/DS1	Moist sal savannah	M.Tr/27/7(a)	Upper alluvial savannah
3C/C3	Moist mixed deciduous forests (without sal)		..
3C/C3a	West Gangetic moist deciduous forest	M.Tr/E4	N. Indian climax moist deciduous forest
3C/C3b	East Himalayan moist deciduous forest	M.Tr/E6	E. Himalayan moist deciduous forest
3C/C3/2S1	Northern secondary moist mixed deciduous forest	M.Tr./2S/6(b)	Northern secondary moist deciduous forest
3C/C3/2S2	Euphorbiaceous scrub		..
3/E1	*Terminalia tomentosa* forest	M.Tr/E5	N. Indian *Terminalia*
3/1S1	Low alluvial savannah woodland (*Salmalia-Albizzia*)	M.Tr/2S/7(b)	Lower alluvial savannah
3/1S2	Eastern hollock forests (*Terminalia myriocarpa*)	M/Tr/1S/7(b)	

APPENDIX C (i)—*contd.*

1	2	3	4
	Subgroup 3C—North Indian moist deciduous forests—*contd.*		**Group 3b—Northern tropical moist deciduous forests**—*contd.*
3/1S2a	*Terminalia-Lagerstroemia*	M.Tr/1S/7(c)	U. Assam moist deciduous riverain forest
3/1S2b	*Terminalia-Duabanga*	M.Tr/1S/8(b)	Northern riverain semi-evergreen (*Terminalia-Phoebe*) forest
3/2S1	(Dry bamboo brakes)	D.Tr/E12	Dry bamboo brakes
	GROUP 4—LITTORAL AND SWAMP FORESTS		MOIST TROPICAL SERAL TYPES (PART)
	Subgroup 4A—Littoral forests		..
4A/L1	Littoral forest	M.Tr/1S/1	Beach forest
	Subgroup 4B—Tidal swamp forests	M.Tr/1S/2	Tidal forest
4B/TS1	Mangrove scrub	M.Tr/1S/2(a)	Low mangrove forest
4B/TS2	Mangrove forest	M.Tr/1S/2(b)	Tree mangrove forest
4B/TS3	Saltwater mixed forest (*Heritiera*)	M.Tr/1S/2(c)	Saltwater *Heritiera* forest
4B/TS4 4B/TS4/E1	Brakish water mixed forest (*Heritiera*) Palm swamp	M.Tr/1S/2(d)	Freshwater *Heritiera* forest
	Subgroup 4C—Tropical freshwater swamp forests	M.Tr/1S/4	Tropical valley freshwater swamp forest
4C/FS1	*Myristica* swamp forest		
4C/FS2	Submontane hill-valley swamp forest		
4C/FS3	Creeper swamp forest		
	Subgroup 4D—Tropical seasonal swamp forests	M.Tr/1S/4	Tropical valley freshwater swamp forest (for part only)
4D/SS1	Eastern seasonal swamp forest		..
4D/SS2 4D/SS3 4D/SS4	*Barringtonia* swamp forest *Syzygium cumini* swamp low forest Eastern seasonal swamp low forest (*Caphalanthus*)	M.Tr/1S/4	Tropical valley freshwater swamp forest
4D/SS5	Eastern *Dillenia* swamp forest		..
4D/2S1	(Eastern wet alluvial grassland)		..
	Subgroup 4E—Tropical riparian fringing forests	M.Tr/1S/5	Moist riparian fringing forest
4E/RS1	Riparian fringing forest	M.Tr/1S/5	

APPENDIX C (i)—*contd.*

1	2	3	4
	DRY TROPICAL FORESTS		**DRY TROPICAL FORESTS**
	GROUP 5—TROPICAL DRY DECIDUOUS FORESTS		TROPICAL DRY DECIDUOUS FORESTS
	Subgroup 5A—Southern tropical dry deciduous forests		**Group 4a—Southern tropical dry deciduous forests**
5A/C1	Dry teak bearing forests	4a/C1	Dry teak forests
5A/C1a	Very dry teak forest		
5A/C1b	Dry teak forest		
5A/C2	Dry red sanders bearing forest	4a/C4	Red sanders forest
5A/C3	Southern mixed deciduous forest	4a/C2	South Indian dry mixed deciduous forest
	Subgroup 5B—Northern tropical dry deciduous forests		**Group 4b—Northern tropical dry deciduous forests**
5B/C1	Dry sal-bearing forests	4b/C2	Dry sal forests
5B/C1a	Dry siwalik sal forest		
5B/C1b	Dry plains sal forest		
5B/C1c	Dry peninsular sal forest		
5B/C2	Northern mixed deciduous forest	4b/C1	Northern dry mixed deciduous forests
5/DS1	Dry deciduous scrub forest	D.Tr/2S2	Dry deciduous scrub
5/DS2	Dry savannah forest	D.Tr/2S/3	Dry savannah
5/DS3	*Euphorbia* scrub	5a/C3	Southern *Euphorbia* semi-desert scrub
		5b/C3	Northern *Euphorbia* scrub
5/DS4	Dry grassland	D.Tr/2S/3	Dry savannah
5/E1	*Anogeissus pendula* forest	D.Tr/E6	*Anogeissus pendula* forest
5/E1/DS1	*Anogeissus pendula* scrub		..
5/E2	*Boswellia* forest	D.Tr/E4	*Boswellia* forest
5/E3	*Babul* forest	D.Tr/E8	*Babul* forest
5/E4	*Hardwickia* forest	D.Tr/E3	*Hardwickia* forest
5/E5	*Butea* forest	D.Tr/E5	*Butea* forest
5/E6	*Aegle* forest	D.Tr/E7	*Aegle* forest
5/E7	Laterite thorn forest	D.Tr/E9	Laterite thorn forest
5/E8	Saline/alkaline scrub savannah	D.Tr/E11	Gangetic saline scrub
5/E8a	Low level *Phoenix*		
5/E8b	(*Salvadora* scrub)		
5/E8c	*Babul* scrub		

APPENDIX C (i)—*contd.*

1	2	3	4
5/E9	Dry bamboo brakes	D.Tr/E12	Dry bamboo brake
5/1S1	Dry tropical riverain forest	D.Tr/1S/1	Southern dry tropical riverain forest
5/1S2	*Khair-sissu* forest	M.Tr/1S/6 D.Tr/1S/2	*Khair-sissoo* forest
5/1S3	Inundation *babul* forest	D.Tr/1S/4	Inundation *babul* forest
3/2S1	Secondary dry deciduous forest	D.Tr/2S/1	Secondary dry deciduous forest
	GROUP 6—TROPICAL THORN FORESTS		TROPICAL THORN FORESTS
	Subgroup 6A—Southern tropical thorn forests		**Group 5a—Southern tropical thorn forests**
6A/C1	Southern thorn forest	5a/C1	Southern Cutch thorn forest
6A/C2	Carnatic umbrella thorn forest	5a/C2	Carnatic umbrella thorn forest
6A/DS1	Southern thorn scrub		..
6A/DS2	*Euphorbia* scrub	5a/C3	Southern *Euphorbia* semi-desert scrub
	Subgroup 6B—Northern tropical thorn forests		**Group 5b—Northern tropical thorn forests**
6B/C1	Desert thorn forest	5b/C1	Northern desert thorn forest
6B/C2	Ravine thorn forest	5b/C2	Northern *Acacia* scrub
6B/DS1	*Zizyphus* scrub		..
6B/DS2	*Euphorbia* scrub	5b/C3	Northern *Euphorbia* scrub
6/E1	(*Euphorbia* scrub)	5a/C3 5/bC3	Southern *Euphorbia* semi-desert scrub Northern *Euphorbia* scrub
6/E2	*Acacia senegal* forest	5b/C1	Northern desert thorn forest
6/E3	*Rann* saline thorn forest		..
6/E4	*Salvadora* scrub		..
6/E4/DS1	*Cassia auriculata* scrub		..
6/1S1	Desert dune scrub	D.Tr/F10	Inland dune scrub

APPENDIX C (i)—*contd.*

1	2	3	4
	GROUP 7—TROPICAL DRY EVERGREEN FORESTS		TROPICAL DRY EVERGREEN FORESTS
7/C1	Tropical dry evergreen forest	6/C1	Tropical dry evergreen forest
7/DS1	Tropical dry evergreen scrub		
	MONTANE SUBTROPICAL FORESTS GROUP 8—SUBTROPICAL BROADLEAVED HILL FORESTS		**MONTANE SUBTROPICAL FORESTS**
	Subgroup 8A—Southern subtropical broadleaved hill forests		**Group 7a—Southern subtropical wet hill forests**
8A/C1	Nilgiri subtropical hill forest	7a/C1	Nilgiri subtropical evergreen forest
8A/C1/E1	Reed brakes (*Ochlandra*)		..
8A/C1/DS1	South Indian tropical hill savannah (woodland)	S.Tr/2S/1	Nilgiri subtropical hill savannah
8A/C2	Western subtropical hill forest	7a/C3	Bombay subtropical evergreen forest
8A/C3	Central Indian subtropical hill forest	7a/C4	Central Indian subtropical evergreen forest
	Subgroup 8B—Northern subtropical broadleaved wet hill forests		**Group 7b—Northern subtropical wet hill forests**
8B/C1	East Himalayan subtropical wet hill forest	7b/C1	Bengal subtropical hill forest
8B/C2	Khasi subtropical wet hill forest	7b/C2	Assam subtropical hill forest
8B/2S1	(Assam subtropical pine forest)	8/C2	Assam-Burma pine forests
8B/DS1	Assam subtropical hill savannah woodland		..
	GROUP 9—SUBTROPICAL PINE FORESTS		GROUP 8—SUBTROPICAL PINE FORESTS
9/C1	Himalayan subtropical pine forests	8/C1	Himalayan subtropical pine forest (Also *see* 4b/C2, Dry sal forests, corresponding to 5B/C1a in the revised classification)
9/C1a	Siwalik chir pine forest		
9/C1b	Himalayan chir pine forest		
9/C1/DS1	Himalayan subtropical scrub		..
9/C1/DS1a	*Carissa* scrub		..
9/C1/DS1b	*Dodonaea* scrub		..
9/C1/DS1c	*Rhus parviflora* scrub		..
9/C1/DS2	Subtropical *Euphorbia* scrub		..

APPENDIX C (i)—*contd.*

1	2	3	4
9/C2	Assam subtropical pine forest	8/C2	Assam-Burma pine forests
9/C2/DS1	Assam subtropical pine savannah		..
	GROUP 10—SUBTROPICAL DRY EVERGREEN FORESTS		GROUP 9—SUBTROPICAL DRY EVERGREEN FORESTS
10/C1	Subtropical dry evergreen forests	9/C1	Olive forests
10/C1a	*Olea cuspidata* scrub forest		
10/C1b	*Acacia modesta* scrub forest		
10/C1/DS1	*Dodonaea* scrub		..
	MONTANE TEMPERATE FORESTS GROUP 11—MONTANE WET TEMPERATE FORESTS		**MONTANE TEMPERATE FORESTS**
	Subgroup 11A—Southern montane wet temperate forests		**Group 10a—Southern wet temperate forests**
11A/C1	Southern montane wet temperate forest	10a/C1	Southern wet temperate forest
11A/C1/DS1	Southern montane wet scrub		..
11A/C1/DS2	Southern montane wet grassland		..
	Subgroup 11B—Northern montane wet temperate forests		**Group 10B—Northern wet temperate forests**
11B/C1	East Himalaya wet temperate forests	10b/C1	East Himalayan wet temperate forest
11B/C1a	Lauraceous forest	10b/C1(a)	Laurel (*Machilus-Michelia* forest
11B/C1b	*Buk* oak forest (*Quercus lamellosa*)	10b/C1(b)	Buk oak (*Quercus lamellosa*) forest
11B/C1c	High-level oak forest	10b/C1(c)	High level oak (*Q. pachyphylla*
11B/C2	Naga Hills wet temperate forest	10b/C2	Assam-Burma wet temperate forest
	GROUP 12—HIMALAYAN MOIST TEMPERATE FORESTS		GROUP 11—HIMALAYAN MOIST TEMPERATE FORESTS
12/C1	Lower West Himalayan temperate forests	11/C1	Lower oak-coniferous (*Quercus incana-Cedrus* forests
12/C1a	*Ban* oak forest (*Quercus incana*)	11/C1a	*Ban* oak forest (*Q. incana*
12/C1b	*Moru* oak forest (*Quercus dilatata*	11/C2(a)	*Moru* oak forest (*Q. dilatata*
12/C1c	Moist deodar forest (*Cedrus*	11/C1(b)	Deodar forest (*Cedrus*

APPENDIX C (i)—*contd.*

1	2	3	4
12/C1d	Western mixed coniferous forest	11/C2(b)	Western mixed coniferous forest
12/C1e	Moist temperate deciduous forest	Tp/E2(a)	Temperate moist deciduous forest
12/C1f	Low level blue pine forest (*P. wallichiana*)	Tp/1S/3	Lower blue pine forest
12/C1/DS1	Oak scrub	Tp/2S/1	Oak scrub
12/C1/DS2	Himalayan temperate secondary scrub	Tp/2S/2	Secondary temperate scrub
12/C2	Upper broadleaved and coniferous forests		..
12/C2a	*Kharsu* oak forest (*Q. semecarpifolia*)	11/C3(a)	*Kharsu* oak forest (*Q. semecarpifolia*).
12/C2b	West Himalayan upper oak/fir forest	11/C3(b)	Western oak-fir (*Abies*) forest
12/C2c	(Moist temperate deciduous forest)	Tp/E2(a)	Temperate moist deciduous forest
12/C3	East Himalayan moist temperate forests		
12/C3a	East Himalayan mixed coniferous forest	11/C1(c) 11/C3(c)	Eastern oak-hemlock (*Tsuga*) forest
12/C3b	*Abies delavayi* forest		Eastern oak-fir (*Abies*) forest ..
12/DS1	Montane bamboo brakes	Tp/2S/4	Temperate bamboo brake
12/DS2	Himalayan temperate parkland	Tp/2S/3	Thach parkland
12/DS3	Himalayan temperate pastures		..
12/E1	Cypress forest	Tp/E1	Cypress forest
12/1S1	Alder forest	Tp/1S/1	Alder woods
12/1S2	Riverain blue pine forest	Tp/1S/3	Lower blue pine forest
12/2S1	Low-level blue pine forest	Tp/1S/3	Lower blue pine forest
	GROUP 13—HIMALAYAN DRY TEMPERATE FORESTS		GROUP 12—HIMALAYAN DRY TEMPERATE FORESTS
13/C1	Dry broadleaved and coniferous forest (*Quercus ilex*/*P. gerardiana*)	12/C1	Dry temperate mixed evergreen forest
13/C2	Dry temperate coniferous forest		
13/C2a	*Neoza* pine forest (*P. gerardiana*)		
13/C2b	Dry deodar forest (*C. deodara*)	12/C2	Dry temperate coniferous forest
13/C3	(West Himalayan dry temperate deciduous forest)	Tp/E2(b)	Temperate dry deciduous forest

APPENDIX C (i)—*concld.*

1	2	3	4
13/C3/DS1	*Pohu* scrub		..
13/C3/DS2	Dry temperate scrub		..
13/C4	West Himalayan high-level dry blue pine forest (*P. wallichiana*)		..
13/C5	West Himalayan dry juniper forest (*J. macropoda*)		..
13/C6	East Himalayan dry temperate coniferous forest	13/C1	Alpine fir/birch forest
13/C6/E1	Larch forest (*Larix griffithiana*)	13/1S/2	Larch forest
13/C7	East Himalayan dry juniper / birch forest (*J. wallichiana*)	13/C1	Alpine fir/birch forest
13/1S1	*Hippophae-Myricaria* scrub	Tp/1S/2	Temperate *Hippophae* scrub
13/1S2	*Populus/Salix* forest		..
13/1S3	(Western high-level dry blue pine)	13/1S/1	High level blue pine forest
	SUBALPINE FORESTS		**ALPINE FORESTS**
	GROUP 14—SUB-ALPINE FORESTS		GROUP 13—ALPINE FORESTS
14/C1	West Himalayan subalpine birch/fir forests (*Betula/Abies*)	13/C1	Alpine fir-birch forest
14/C1a	Fir forest		
14/C1b	Birch/fir forest		
14/C2	East Himalayan subalpine birch/fir forest		
14/1S1	(*Hippophae/Myricaria* scrub)	Tp/1S/2	Temperate *Hippophae* scrub
14/1S2	(Deciduous subalpine scrub)	15	Dry alpine scrub
14/2S1	Subalpine blue pine forest (*P. wallichiana*)	13/1S/1	High level blue pine forest
14/DS1	Subalpine pastures	14	Moist alpine scrub
	ALPINE SCRUB		
	GROUP 15—MOIST ALPINE SCRUB		GROUP 14—MOIST ALPINE SCRUB
15/C1	Birch/*Rhododendron* scrub forest	13/C2	Birch-*Rhododendron* forest
15/C2	Deciduous alpine scrub	14	Moist alpine scrub
15/C2/E1	Dwarf *Rhododendron* scrub		
15/C3	Alpine pastures		..
	GROUP 16—DRY ALPINE SCRUB		GROUP 15—DRY ALPINE SCRUB
16/C1	Dry alpine scrub	15	Dry alpine scrub
16/E1	Dwarf juniper scrub	14	Moist alpine scrub

APPENDIX C (ii)

CONCORDANCE TABLE FOR SAL TYPES

Type No.	Revised Survey	Type No.	Preliminary Survey	Type No.	Regeneration and management of sal. *Ind. For. Rec.* XIX(III) (1933)
1	2	3	4	5	6
3C/C1	VERY MOIST SAL-BEARING FORESTS	3B/C2	WET SAL FORESTS	D	WET SAL
3C/C1a	Very moist hill sal	3B/C2/D1	Eastern hill sal	D1	(Wet Eastern hill sal (Easttern Hill Type p. 59)
3C/C1a(i)	Eastern hill sal	3B/C2/D1a	East Himalayan sal	D1(a)	East Himalayan sal (East Himalayan subtype p. 59)
3C/C1a(ii)	*Khasi* hill sal	3B/C2/D1b	Khasi hill sal	D1/(b)	Khasi hill sal (Khasi hill subtype p. 85)
3C/C1b	Very moist *bhabar* sal	M.Tr/2S/5a 3B/C2/D2	Wet plains sal Eastern *bhabar* sal	Da	(Wet) Eastern bhabar sal (Eastern bhabar type p. 61, 88)
3C/C1b(i)	Eastern upper *bhabar* sal	3B/C2/D2a	Bamba sal	D2(a)	Upper bhabar sal (Bamba subtype p. 61)
3C/C1b(ii)	Eastern lower *bhabar* sal	3B/C2/D2b	Sivok sal	D2(b)	Lower bhabar sal (Sivok subtype p. 64)
3C/C1c	Very moist *tarai* sal	3B/C2/D3 M.Tr/2S/5(a)	Eastern *tarai* sal	D3	(Wet) Eastern tarai sal (Eastern tarai type p. 72, 91)
3C/C1d	Very moist peninsular (coastal) sal	M.Tr/2S/5(b)	Coastal sal	C	Coastal sal (p. 107)
3C/C2	MOIST SAL BEARING FORESTS	3B/C1	MOIST SAL FORESTS	B	MOIST SAL
3C/C2a	Moist Siwalik sal	3B/C1/B1	Moist Siwalik sal	B1	Moist western Hill sal (Moist Siwalik type p. 35)

3C/C2b	Moist *bhabar* sal	3B/C1/B3	High level alluvium sal	B3	Moist (Gangetic) high level alluvial sal (High level alluvium type p. 37)
3C/C2b(i)	Moist *bhabar* sal				
3C/C2b(ii)	Moist *damar* sal				
3C/C2c	Moist *tarai* sal	3B/C1/B6	West *tarai* sal	B6	West tarai sal (West tarai type p. 54)
3C/C2d	Moist plains sal			B4,B5	Moist (Gangetic) low level and high level alluvial sal.
3C/C2d(i)	Western light alluvium sal	3B/C1/B4	S. Kheri sal	B4	Moist (Gangetic) low level alluvial sal (S. Kheri type p. 47)
3C C2d(ii)	Eastern heavy alluvium sal	3B/C1/B5	Old alluvium sal	B5a	Moist (Gangetic) low level clayey alluvial sal (Old alluvium type, including B5a Gorakhpur subtype p. 80)
3C/C2d(i)App.	Frosty *chandar* sal	3B/C1/B4 App.	*Chandar* sal	B4 App.	Frosty sal chandars (Chandar subtype p. 49)
3C/C2d(ii)App.	Kamrup sal	..	Old alluvium sal	B5 App.	B5 App. Kamrup alluvial sal (p. 76)
3C/C2e	Moist peninsular sal	3B/C1/B2	Moist peninsular sal	B2	Moist Peninsular sal (Moist Peninsular type pp. 99, 113, 120)
3C/C2e(i)	High level sal	3B/C1/B2a	Supkhar sal	B2(a)	Moist Peninsular high level sal (Supkhar subtype p. 120)
3C/C2e(ii)	Low level sal	3B/C1/B2b	S. Raipur sal	B2(b)	Moist Peninsular low level sal (S. Raipur subtype p. 121)
3C/C2e(iii)	Valley sal	3B/C1/B2c	Singhbhum valley sal (including B2 App. Frosty valley sal)	B2(c)	Moist Peninsular valley sal (Singhbhum valley subtype p. 99, 120, including B2 App. Frosty valley sal p. 106)

APPENDIX C (ii)—*concld.*

1	2	3	4	5	6
3C/DS1	Moist sal savannah	M.Tr/2S/7(a)	N. Indian upper alluvial savannah forest		..
5B/C1	DRY SAL-BEARING FORESTS	4B/C2	DRY SAL FORESTS	A	DRY SAL FORESTS
5B/C1a	Dry siwalik sal	4B/C2	...	A1	Dry Siwalik sal (Dry Siwalik type p. 32)
5B/C1b	Dry plains sal	4B/C2	Dry Gangetic alluvial sal	A2	Dry Gangetic alluvial (Dry Gangetic type p. 33)
5B/C1c	Dry peninsular sal	4B/C2	Dry peninsular sal	A3	Dry Peninsular sal (Dry Peninsular type p. 95)

APPENDIX D (i)

NAME CHANGES

List of species according to old (obsolete) names.

Obsolete name	Current name
Abies webbiana Lindl.	*Abies spectabilis* (D.Don) Spach.
Acronychia laurifolia Bl.	*Acronychia pedunculata* (Linn.) Miq.
Aerva tomentosa Forsk.	*Aerva javanica* (Burm. f.) Spreng.
Agrostis maxima Roxb.	*Thysanolaena maxima* (Roxb.) Oktze.
Alangium begoniifolium Baill.	*Alangium chinense* (Lour.) Rehder.
Alangium lamarckii Thw.	*Alangium salvifolium* (Linn. f.) Wang.
Albizzia stipulata Boiv.	*Albizzia chinensis* (Osbeck) Merr.
Alpinia nutans Roscoe	*Alpiria speciosa* (Wendl.) Schum.
Alseodaphne owdenii Parker.	*Persea owdenii* (Parker) Kostermans
Alsodeia bengalensis Wall.	*Rinorea bengalensis* (Wall.) Okze.
Amoora rohituka W. & A.	*Aphanamixis polystachya* (Wall.) Parker
Andromeda ovalifolia Wall.	*Lyonia ovalifolia* (Wall). Drude.
Andropogon aciculatus Retz.	*Chrysopogon aciculatus* (Retz.) Trin.
Andropogon annulatus Forsk.	*Dichanthium annulatum* (Forsk.) Stapf.
Andropogon assimilis Steud.	*Capillipedium assimile* (Steud.) A. Camus.
Andropogon coloratus Nees.	*Cymbopogon coloratus* (Nees) Stapf.
Andropogon contortus Linn.	*Heteropogon contortus* (Linn.) Beauv. ex. R. & S.
Andropogon foveolatus Del.	*Eremopogon foveolatus* (Del.) Stapf.
Andropogon gryllus Linn.	*Chrysopogon gryllus* (Linn.) Trin.
Andropogon halepensis Brot.	*Sorghum halepense* (Linn.) Pers.
Andropogon jwarancusa Jones.	*Cymbopogon jwarancusa* (Jones) Schult.
Andropogon micranthus Kunth.	*Capillipedium parviflorum* (R. Br.) Stapf.
Andropogon monticola Schult	*Chrysopogon fulvus* (Spreng.) Chiov.
Andropogon muricatus Retz.	*Vetiveria zizanioides* (Linn.) Nash.
Andropogon nardus Linn.	*Cymbopogon nardus* (Linn.) Rendle.
Andropogon pertusus (Linn.) Willd.	*Bothriochloa pertusa* (Linn.) A. Camus
Andropogon polyneuros Steud.	*Cymbopogon polyneuros* (Steud.) Stapf.
Aneilema nudiflorum R. Br.	*Murdannia nudiflorum* (Linn.) Brenan
Anthistiria anathera Nees. ex Steud.	*Themeda anathera* (Nees. ex Steud) Hack.
Anthistiria arundinacea Roxb.	*Themeda arundinacea* (Roxb.) Ridley
Anthistiria ciliata L.f.	*Themeda quadrivalvis* (Linn.) O. Ktze.
Anthistiria gigantea Cav.	*Themeda arundinacea* (Roxb.) Ridley
Anthistiria imberbis Retz.	*Themeda triandra* Forsk.
Anthocephalus indica R. Rich.	*Anthocephalus cadamba* Miq.
Apluda varia Hack. subsp. *mutica* Hack.	*Apluda mutica* Linn.
Ardisia humilis A.DC.	*Ardisia solanacea* (Poir.) Roxb.
Aristida adscensionis Hook . f. non Linn.	*Aristida depressa* Retz.
Arthraxon ciliaris Hk. f.	*Arthraxon quartinianus* (A. Rich.) Nash
Artocarpus integrifolius non L. f.	*Artocarpus heterophyllus* Lamk.
Arundinaria aristata Gamble	*Thamnocalamus aristatus* E.G. Camus

APPENDIX D (i)—*contd.*

Obsolete name	Current name
Arundinaria callosa Munro	*Chimonobambusa callosa* (Munro) Nakai
Arundinaria falconeri (Hook. f.) Benth. etc. Hook f.	*Thamnocalamus falconeri* Hook. f.
Arundinaria griffithiana Munro	*Chimonobambusa griffithiana* (Munro) Nakai
Arundinaria spathiflora Trin.	*Thamnocalamus sapthiflorus* (Trin.) Munro
Arundinella brasiliensis Reddi	*Arundinella intricata* Hughes
Arundinella capillaris Hook. f.	*Arundinella setosa* Trin.
Arundinella wallichii Nees ex. Steud.	*Arundinella bengalensis* (Spreng.) Druce
Axonopus cimicinus Beauv.	*Alloteropsis cimicina* (Linn.) Stapf
Balanites roxburghii Planch.	*Balanites aegyptiaca* (Linn.) Delile
Balanocarpus utilis Bedd.	*Hopea utilis* (Bedd.) Bole
Balsamodendron caudatum W. & A.	*Commiphora caudata* (W. & A.) Engl.
Balsamodendron mukul Hook ex Stocks	*Commiphora mukul* (Hook ex Stocks) Engl.
Barringtonia speciosa Forst	*Barringtonia asiatica* (Linn.) Kurz
Bassia butyracea Roxb.	*Diploknema butyracea* (Roxb.) H.J. Lamb.
Bassia elliptica Dall.	*Palaquium ellipticum* (Dalz.) Engler
Bassia latifolia Roxb.	*Madhuca indica* Gmel.
Berberis nepalensis Spreng. in part	*Mahonia napaulensis* DC.
Bombax insigne Wall.	*Salmalia insignis* (Wall.) Schott. & Endl.
Bombax malabaricum DC.	*Salmalia malabarica* (DC.) Schott. & Endl.
Breweria latifolia Benth. ex. Cl.	*Bonamia latifolia* (Hochst. ex Steud) Santapau
Bromus patulus Mert. & Koch.	*Bromus japonicus* Thumb.
Bruguiera gymnorhiza Lamk	*Bruguiera conjugata* Linn.
Bucklandia populnea R. Br. ex. Griff.	*Symingtonia populnea* (R. Br.) Van Steenis
Bursera serrata Wall. ex. Colebr.	*Protium serratum* (Wall. ex Colebr.) Engl.
Butea frondosa Koenig ex Roxb.	*Butea monosperma* (Lamk.) Taub.
Caesalpinia bonducella (Linn.) Fleming	*Caesalpinia bonduc* (Linn.) Roxb.
Calophyllum spectabile Willd.	*Calophyllum soulattri* Burm. f.
Calophyllum tomentosum T. Anders. non Wt.	*Calophyllum elatum* Bedd.
Capparis aphylla Roth	*Capparis decidua* (Forsk.) Pax.
Capparis horrida Linn.	*Capparis zeylanica* Linn. non. Hk. f. & Th.
Carallia integerrima DC.	*Carallia brachiata* (Lour.) Merr.
Carapa moluccensis Lam.	*Xylocarpus moluccensis* (Lam.) Roem.
Carapa obovata Bl.	*Xylocarpus granatum* Koenig.
Carissa spinarum auct. non Linn.	*Carissa opaca* Stapf.
Cenchrus catharticus Del.	*Cenchrus barbatus* Schum.
Ceriops candolleana Arn.	*Ceriops tagal* (Perr.) C. V. Robins.
Chloris barbata (Linn.) Sw.	*Chloris inflata* Link.
Chloris incompleta Roth.	*Chloris dolichostachya* Lag.
Chickrassia tabularis *Chukrasia tabularis* A. Juss.	*Chukrasia velutina* Wt. & Arn.
Chrysopogon montanus Trin. ex Spreng	*Chrysopogon fulvus* (Spreng.) Chiov.
Clerodendron infortunatum auct. non Linn.	*Clerodendrum viscosum* Vent.
Cocculus villosus DC.	*Cocculus hirsutus* (Linn.) Diels.
Cochlospermum gossypium DC.	*Cochlospermum religiosum* (Linn.) Alston
Coix lachryma-jobi var. *gigantea* Stapf. ex. Hk. f.	*Coix gigantea* Koen. ex. Roxb.
Corchorus acutangulus Lamk.	*Corchorus aestuans* Linn. non. Forsk.
Cordia obliqua Willd.	*Cordia dichotoma* Forst. f.

APPENDIX D (i)—*contd.*

Obsolete name	Current name
Cornus capitata Wall. ex Roxb.	*Benthamidia capitata* (Wall.) Hara
Cretaeva religiosa *Crataeva roxburghii* Br.	*Crataeva unilocularis* Ham.
Cyclostemon lancifolius Hook f.	*Drypetes lancifolia* (Hk. f.) Pax. & Hoffm.
Daedalacanthus purpurascens A. Anders.	*Eranthemum purpurascens* Nees.
Derris uliginosa Benth.	*Derris trifoliata* Lour
Dillenia pulcherrima Kurz.	*Dillenia aurea* Sm.
Diospyros embryopteris Pers.	*Diospyros peregrina* (Gaertn.) Gurke
Dipterocarpus griffithi Miq.	*Dipterocarpus grandiflorus* Bl.
Dipterocarpus incanus Roxb.	*Dipterocarpus alatus* Roxb.
Dipterocarpus turbinatus var. *andamanica* King.	*Dipterocarpus gracilis* Bl.
Dolichandrone crispa Seem.	*Dolichandrone atrovirens* (Heyne ex Roth) Spragne
Dolichandrone rheedii Seem.	*Dolichandrone spathacea* (Linn. f.) Schum.
Duabanga sonneratioides Ham.	*Duabanga grandiflora* (Roxb.) Walp.
Echinocarpus assamicus Benth.	*Sloanea assamica* Rehder & Wilson
Echinocarpus dasycarpa Benth.	*Sloanea dasycarpa* (Benth.) Hemsl.
Eleusine aegyptiaca Desf.	*Dactyloctenium aegyptium* (Desf.) Beauv.
Eleusine aristata Ehrenb.	*Dactyloctenium scindicum* Boises.
Eleusine flagellifera Nees.	*Eleusine compressa* (Forsk.) Aschers. et Schwf. ex. Christensen
Embelia robusta C. B. Cl. non Roxb.	*Embelia tsjeriam-cottam* (R. & S.) A. Dc.
Endospermum malaccense	*Endospermum chinense* Benth.
Entada scandens Benth.	*Entada phaseoloides* (L.) Merrill.
Eragrostis cynosuroides Beauv.	*Desmostachya bipinnata* (Linn.) Stapf.
Erianthus elephantinus Hook. f.	*Erianthus ravennae* (Linn.) P. Beauv.
Erythrina indica Lamk.	*Erythrina variegata* Linn. var. *orientalis* (Linn.) Merr.
Eugenia caryophyllaea Wt.	*Syzygium caryophyllatum* (Linn.) Alston.
Eugenia operculata *Eugenia cerasoides* Roxb.	*Syzygium cerasoideum* (Roxb.) Raizada
Eugenia jambolana Lamk.	*Syzygium cumini* (Linn.) Skeels.
Eulalia argentea Brongn.	*Eulalia trispicata* (Schult.) Heur.
Evodia roxburghiana Benth.	*Evodia lunu-ankenda* (Gaertn.) Merr.
Flacourtia ramontchi L' Herit. *Flacourtia sepiaria* Roxb.	*Flacourtia indica* (Burm. f.) Merr.
Flemingia Roxb. ex. Ait.	*Moghania* (Linn.) St. Hil. ex Jacks.
Flueggea leucopyros (Koen.) Willd.	*Securinega leucophyrus* (Wild.) M. Arg.
Flueggea microcarpa Bl.	*Securinega virosa* (Roxb. ex Willd.) Pax & Hoffm.
Gardenia lucida Roxb.	*Gardenia resinifera* Roth.
Gracilea royleana Hook. f.	*Melanocenchris jacquemontii* Jaub & Spach.
Grewia populifolia Vahl.	*Grewia tenax* (Forsk). Fiori.
Gyrocarpus americanus auct non Jacq.	*Gyrocarpus jacquinii* Gaertn.
Gymnosporia montana Benth.	*Gymnosporia spinosa* (Forsk.) Fiori
Hardwickia pinnata Roxb.	*Kingiodendron pinnatum* (Roxb.) Harms.
Hedera helix auct non Linn.	*Hedera nepalensis* K. Koch.
Heleochloa schoenoides (Linn.) Host.	*Crypsis schoenoides* (Linn.) Lamk.
Hemicyclia sepiaria W. & A.	*Drypetes sepiaria* (W.&A.) Pax. & Hoffm.
Hemicyclia venusta Thw.	*Drypetes venusta* (Wight.) Pax. & Hoffm.

APPENDIX D (i)—*contd.*

Obsolete name	Current name
Heterophragma roxburghii A.DC.	*Heterophragma quadriculare* (Roxb.) K. Schum.
Imperata arundinacea Cyrill.	*Imperata cylindrica* (Linn.) Beauv.
Ipomoea biloba Forsk.	*Ipomoea pes-caprae* (Linn.) Sweet.
Ischaemum angustifolium Hack.	*Eulaliopsis binata* (Retz.) C.E. Hubb.
Ischaemum laxum R. Br.	*Sehima nervosum* (Rottl.) Stapf.
Ischaemum notanum Hack.	*Sehima notana* (Hack.) A. Camus.
Ischaemum sulcatum Hack.	*Sehima sulcatum* (Hack.) A. Camus.
Ixora parviflora Vahl. non Lamk.	*Ixora arborea* Roxb. ex. Sm.
Jambosa formosa Walp.	*Eugenia formosa* Wall.
Jambosa kurzii	*Eugenia kurzii* Duthie
Jambosa praecox	*Eugenia praecox* Roxb.
Jambosa ramosissima	*Eugenia ramosissima* Wall.
Juniperus pseudo-sabina Hk. f. non Fisch. et. Mey.	*Juniperus wallichiana* Hk. f. ex Parl.
Kandelia rheedii W. & A.	*Kandelia candel* (Linn.) Druce.
Kurrimia laipartita Laws.	*Kurrimia indica* (Bedd.) Gamble.
Lagerstroemia flos-reginae Retz.	*Lagerstroemia speciosa* (Linn.) Pers.
Lannea grandis (Dennst.) Engler	*Lannea coromandelica* (Houtt.) Merr.
Leea sambucina Willd.	*Leea indica* (Burm.) Merr.
Leptadenia spartium Wight.	*Leptadenia pyrotechnica* (Forsk.) Decne.
Limonia acidissima Linn.	*Feronia limonia* (Linn.) Swingle
Limonia alata W. & A.	*Pleiospermium alatum* (W. & A.) Swingle
Limonia crenulata Roxb.	*Hesperethusa crenulata* (Roxb.) Roem.
Lindenbergia urticaefolia Lehm.	*Lindenbergia indica* (Linn.) O. Ktze.
Litsea chinensis Lam.	*Litsea glutinosa* (Lour.) C. B. Robin.
Litsea polyantha Juss.	*Litsea monopetala* (Roxb.) Pers.
Loranthus longiflorus Desr.	*Dendrophthoe falcata* (Linn. f.) Etting.
Madhuca butyracea (Roxb.) Machride	*Diploknema butyracea* (Roxb.) H. J. Lamb.
Madhuca latifolia (Roxb.) Macbride	*Madhuca indica* Gmel.
Michelia cathcartii Hk. f. & Th.	*Alcimandra cathcartii* (Hk. f. & Th.) Dandy
Michelia excelsa Bl. ex Wall.	*Michelia doltsopa* Buch-Alam. ex DC.
Miliusa tectona Hutchinson ex. Parkinson	*Saccopetalum tectonum* (Hutchinson) Chatterjee
Mimusops hexandra Roxb.	*Maniklara hexandra* (Roxb.) Dub.
Mimusops littoralis Kurz.	*Manilkara littorallis* (Kurz.) Dub.
Mitrephora prainii King	*Pseuduvaria prainii* (King) Merr.
Mollugo hirta Thunb.	*Glinus lotoides* Linn.
Moringa pterygosperma Gaertn.	*Moringa oleifera* Lamk.
Mucuna imbricata DC.	*Mucuna nigricans* (Lour.) Steud.
Mucuna pruriens Baker non DC.	*Mucuna prurita* Hook.
Murraya exotica Linn.	*Murraya paniculata* (Linn.) Jack.
Myrica nagi Thunb.	*Myrica sapida* Wall.
Nephelium longana Camb.	*Euphoria longana* Lamk.
Nyssa sessiliflora Hk. f. & Th.	*Nyssa javanica* (Bl.) Wang.
Ochlandra brandissi Gamble.	*Ochlandra wightii* (Munro) C.E.C. Fischer
Ochrosia borbonica Kh. f. non Gmel.	*Ochrosia oppositifolia* (Lamk.) K. Schum.
Ocimum canum Sims.	*Ocimum americanum* Linn.
Odina wodier Roxb.	*Lannea coromandelica* (Houtt.) Merr.
Ophioxylon spp. Wight	*Rauwolfia* spp. Linn.

APPENDIX D (i)—*contd.*

Obsolete name	Current name
Osyris arborea Wall. ex A. DC.	*Osyris wightiana* Wall. ex. Wight.
Ougeinia dalbergioides Benth.	*Ougeinia oojeinensis* (Roxb.) Hochreut
Pandanus odoratissimus Roxb.	*Pandanus tectorius* Soland ex Parkinson
Panicum flavidum Retz.	*Paspalidium flavidum* (Retz.) A. Camus
Panicum isachne Roth.	*Brachiaria eruciformis* (J.E. Sm.) Griseb.
Panicum plicatum Willd. (non Lamk.)	*Setaria palmifolia* (Koenig.) Stapf.
Pasania spicata (Syn. *Quercus spicata* Sm.)	*Lithocarpus spicatus* (Sm.) Redh. & Wils.
Pennisetum ciliare Link.	*Cenchrus ciliaris* Linn.
Pennisetum prieurii Kunth.	*Cenchrus prieurii* (Kunth.). Maire
Pergularia extensa N.E. Br.	*Pergularia daemia* (Forsk.) Chiov.
Perotis latifolia Ait.	*Perotis indica* (Linn.) O. Ktze.
Phyllanthus emblica Linn.	*Emblica officinalis* Gaertn.
Picea morinda Link.	*Picea smithiana* (Wall.) Boiss.
Picea morindoides Rehd.	*Picea spinulosa* (Griff.) Henry
Pieris ovalifolia (Wall.) D. Don.	*Lyonia ovalifolia* (Wall.) Drunde
Pinus excelsa Wall.	*Pinus wallichiana* A. B. Jackson
Pinus khasya Royle ex Parl.	*Pinus insularis* Endl.
Pinus longifolia Roxb.	*Pinus roxburghii* Sargent
Planchonia andamanica King	*Planchonia valida* Bl.
Plectronia didyma Kurz.	*Canthium dicoccum* (Gaertn.) Merr.
Poa interrupta Lamk.	*Eragrostis interrupta* (Lamk.) Beauv.
Poa unioloides Retz.	*Eragrostis unioloides* (Retz.) Nees ex Steud.
Podophyllum emodi Wall.	*Podophyllum hexandrum* Royle.
Pogonatherum saccheroideum Beauv.	*Pogonatherum paniceum* (Lamk.) Hack.
Pollinia argentea Trin.	*Eulalia trispicata* (Schult.) Henr.
Pollinia ciliata Trin.	*Microstegium ciliatum* (Trin.) A. Camus
Pollinia hirtifolia Hack.	*Eulalia hirtifolia* (Hack.) Ktze.
Pollinia mollis Hack.	*Eulalia mollis* (Grisele). Ktze.
Polytoca barbata Stapf ex. Hook. f.	*Chionachne koenigii* (Spreng.) Thw.
Pongamia glabra Vent.	*Pongamia pinnata* (Linn.) Pierre
Prunus padus (non Linn.) Hk. f.	*Prunus cornuta* Steud.
Pteris aquilina Linn.	*Pteridium aquilinum* Kuhn.
Puliculum articulatum (Trin.) Stapf ex Haines.	*Pseudopogonatherum contortum* (Brongn.) A. Camus.
Pyrus foliolosa Wall.	*Sorbus foliolosa* (Wall.) Spach.
Rhizophora conjugata Kurz. non Linn.	*Rhizophora candelaria* DC.
Rhododendron anthopogon Don.	*Rhododendron hypenanthum* Balf.
Rottboellia perforata Roxb.	*Mnesithea laevis* (Retz.) Kunth.
Saccharum arundinaceum Retz.	*Erianthus arundinaceus* (Retz.) Jesweit
Saccharum fuscum Roxb.	*Sclerostachya fusca* (Roxb.) A. Camus
Saccharum munja Roxb.	*Erianthus munja* (Roxb.) Jesweit
Saccharum narenga Ham.	*Narenga porphyrocoma* (Hance) Bor
Saccopetalum tomentosum Hk. f. & Th.	*Miliusa tomentosa* (Roxb.) J. Sinclair
Sapindus trifoliatus Hiren.	*Sapindus emarginatus* Vahl.
Sarcostemma brevistigma W. & A.	*Sarcostemma acidum* (Roxb.) Voigt.
Scaevola koenigii Vahl.	*Scaevola frutescens* (Mill.) Krause.
Schleichera trijuga Willd.	*Schleichera oleosa* (Lour) Oken.
Scutia indica Brongn.	*Scutia myrtina* (Burm.) Kurz.
Sideroxylon tomentosum Roxb.	*Xantolis tomentosa* (Roxb.) Rafin.

APPENDIX D (i)—*concld.*

Obsolete name	Current name
Smilax macrophylla Roxb.	*Smilax zeylanica* Linn.
Sonneratia acida Linn. f.	*Sonneratia caseolaris* (Linn.) Engler
Spatholobus roxburghii Benth.	*Butea parviflora* Roxb.
Spermacoce hispida Linn.	*Borreria hispida* (Linn.) Schum.
Spondias mangifera Willd.	*Spondias pinnata* (Linn. f.) Kurz.
Sporobolus indicus Hook. f. Non R. Br.	*Sporobolus elongatus* R. Br.
Sporobolus arabicus Boiss. *Sporobolus pallidus* (Nees) Boiss.	*Sporobolus marginatus* Hochst ex Rich.
Stephegyne parvifolia Korth.	*Mitragyna parvifolia* (Roxb.) Korth.
Sterculia alata Roxb.	*Pterygota alata* (Roxb.) R. Br.
Sterculia campanulata Wall. ex Masters.	*Pterocymbium tinctorium* (Blanco) Merr.
Sterculia colorata Roxb.	*Firmiana colorata* (Roxb.) R. Br.
Stereospermum chelonoides auct. non *nisipartim* A.DC.	*Stereospermum personatum* (Hassak.) Chatt.
Stereospermum xylocarpum Benth. & Hk. f.	*Radermachera xylocarpa* (Roxb.) K. Schum.
Strobilanthes callosus Nees.	*Carvia callosa* (Nees.) Bremek.
Symplocos spicata Roxb.	*Symplocos laurina* (Retz.) Wall. ex G. Don.
Syzygium jambolanum DC.	*Syzygium cumini* (Linn.) Skeels.
Tamarix articulata Vahl.	*Tamarix aphylla* (Linn.) Karst.
Tamarix gallica auct. non. Linn.	*Tamarix troupii* Hole.
Taraktogenos kurzii King.	*Hydnocarpus kurzii* (King) Warb.
Tecoma undulata G. Don.	*Tecomella undulata* (Smith) Seem.
Teinostachyum dulloosa Gamble.	*Neohouzeaua dullooa* A. Camus.
Ternstroemia japonica auct. non Linn.	*Ternstroemia gymnanthera* (W. & A.) Sprague.
Themeda ciliata (Linn. f.) Hack.	*Themeda quadrivalvis* (Linn.) O. Ktze.
Thysanolaena agrostis Nees.	*Thysanolaena maxima* (Roxb.) O. Ktze.
Tiliacora racemosa Colebr.	*Tiliacora acuminata* (Lamk.) Miers.
Toddalia aculeata Pers.	*Toddalia asiatica* (Linn.) Lamk.
Tragus racemosus Hook. f.	*Tragus biflorus* (Roxb.) Schult.
Triraphis madagascariensis Hk. f.	*Neyraudia arundinacea* (K). Hern.
Tsuga brunoniana Carr.	*Tsuga dumosa* (D. Don.) Eichler.
Turpinia nepalensis W. & A.	*Turpinia cochinchinensis* (Lour). Merr.
Urochloa helopus Stapf.	*Urochloa panicoides* Beauv.
Vallaris heynei Spreng.	*Vallaris solanacea* (Roth). O. Ktze.
Vitex heterophylla Roxb.	*Vitex quinata* (Lour.) F. N. Williams.
Vitis latifolia Roxb.	*Ampelocissus latifolia* (Roxb.) Plach.
Vitis repanda W. & A.	*Cissus repanda* Vahl.
Woodfordia floribunda Salisb.	*Woodfordia fruticosa* (Linn.) Kurz.
Zanthoxylum budrunga DC. *Zanthoxylum rhetsa* (Roxb.) D.C.	*Fagara budrunga* Roxb.
Zizyphus jujuba Lamk. non Linn.	*Zizyphus mauratiana* Lamk.
Zizyphus rotundifolia Lamk.	*Zizyphus nummularia* (Burm. f.) W. & A.

APPENDIX D (ii)

NAME CHANGES

List of species according to current names

Current name	Obsolete name
Abies spectabilis (D.Don) Spach.	*Abies webbiana* Lindl.
Acronychia pedunculata (Linn.) Miq.	*Acronychia laurifolia* Bl.
Aerva javanica (Burm. f.) Spreng.	*Aerva tomentosa* Forsk.
Alangium chinense (Lour.) Rehder	*Alangium begoniifolium* Baill.
Alangium salvifolium (Linn. f.) Wang.	*Alangium lamarckii* Thw.
Albizzia chinensis (Osbeck) Merr.	*Albizzia stipulata* Boiv.
Alcimandra cathcartii. (Hk. f. & Th.) Dandy	*Michelia cathcartii* Hk. f. & Th.
Alloteropsis cimicina (Linn.) Stapf.	*Axonopus cimicinus* Beauv.
Alpinia speciosa (Wendl.) Schum.	*Alpinia nutans* Roscoe
Ampelocissus latifolia (Roxb.) Planch	*Vitis latifolia* Roxb.
Anthocaephalus cadamba A. Rich.	*Anthocephalus indica* Miq.
Aphanamixis polystachya (Wall.) Parker	*Amoora rohituka* W. & .A.
Apluda mutica Linn.	*Apluda varia* Hack. subsp. *mutica* Hack.
Ardisia solanacea (Poir.) Roxb.	*Ardisia humilis* A.DC.
Aristida depressa Retz.	*Aristida adscensionis* Hook. F. non Linn.
Arthraxon quartinianus (A. Rich.) Nash.	*Arthraxon ciliaris* Hk. f.
Artocarpus heterophyllus Lamk.	*Artocarpus integrifolius* non L. f.
Arundinella bengalensis (Spreng.) Druce	*Arundinella wallichii* Nees ex. Steud.
Arundinella intricata Hughes	*Arundinella brasiliensis* Raddi
Arundinella setosa Trin.	*Arundinella capillaris* Hook. f.
Balanites aegyptiaca (Linn.) Delile	*Balanites roxburghii* Planch.
Barringtonia asiatica (Linn.) Kurz.	*Barringtonia speciosa* Forst.
Benthamidia capitata (Wall.) Hara	*Cornus capitata* Wall. ex Roxb.
Bonamia latifolia (Hochst. ex Steud.) Santapau	*Breweria latifolia* Benth. ex Cl.
Borreria hispida (Linn.) Schum.	*Spermacoce hispida* Linn.
Bothriochloa pertusa (Linn.) A. Camus.	*Andropogon pertusus* (Linn.) Willd.
Brachiaria eruciformis (J.E.Sm.) Griseb.	*Panicum isachne* Roth.
Bromus japonicus Thunb.	*Bromus patulus* Mert. & Koch.
Bruguiera conjugata Linn.	*Bruguiera gymnorhiza* Lamk.
Butea monosperma (Lamk) Taub.	*Butea frondosa* Koenig ex Roxb.
Butea parviflora Roxb.	*Spatholobus roxburghii* Benth.
Caesalpinia bonduc (Linn.) Roxb.	*Caesalpinia bonducella* (Linn.) Fleming
Canthium dicoccum (Gaertn.) Merr.	*Plectronia didyma* Kurz.
Calophyllum elatum Bedd.	*Calophyllum tomentosum* T. Anders. non Wt.
Calophyllum soulattri Burm. f.	*Calophyllum spectabilis* Willd.
Capillipedium assimile (Steud.) A. Camus.	*Andropogon assimilis* Steud.
Capillipedium parviflorum (R. Br.) Stapf.	*Andropogon micranthus* Kunth.
Capparis decidua (Forsk.) Pax.	*Capparis aphylla* Roth.
Capparis zeylanica Linn. non Hk. f. & Th.	*Capparis horrida* Linn.
Carallia brachiata (Lour.) Merr.	*Carallia integerrima* DC.

APPENDIX D (ii)—*contd.*

Current name	Obsolete name
Carissa opaca Stapf.	*Carissa spinarum* auct. non Linn.
Carvia callosa (Nees.) Bremek.	*Strobilanthes callosus* Nees.
Cenchrus barbatus Schum.	*Cenchrus catharticus* Del.
Cenchrus ciliaris Linn.	*Pennisetum ciliare* Link.
Cenchrus prieurii (Kunth.) Maire	*Pennisetum prieurii* Kunth.
Chionachne koenigii (Spreng.) Thw.	*Polytoca barbata* Stapf. ex. Hork. f.
Cissus repanda Vahl.	*Vitis repanda* W. & A.
Ceriops tagal (Perr.) C. V. Robins.	*Ceriops candolleana* Arn.
Chimonobambusa callosa (Munro) Nakai.	*Arundinaria callosa* Munro
Chimonobambusa griffithiana (Munro) Nakai	*Arundinaria griffithiana* Munro
Chloris inflata Link.	*Chloris barbata* (Linn.) Sw.
Chloris dolichostachya Lag.	*Chloris incompleta* Roth.
Chukrasia velutina Wt. & Arn.	*Chukrasia tabularis* A. Juss.
Chrysopogon aciculatus (Retz.) Trin.	*Andropogon aciculatus* Retz.
Chrysopogon fulvus (Spreng.) Chiov.	*Andropogon monticola* Schult. *Chrysopogon montanus* Trin ex Spreng
Chrysopogon gryllus (Linn.) Trin.	*Andropogon gryllus* Linn.
Clerodendrum viscosum Vent.	*Clerodendron infortunatum* auct. non Linn.
Cocculus hirsutus (Linn.) Diels.	*Cocculus villosus* DC.
Cochlospermum religiosum (Linn. Alston	*Cochlospermum gossypium* DC.
Coix gigantea Koen. ex. Roxb.	*Coix lachryma-jobi* var. *gigantea* Stapf ex. Hk f.
Commiphora caudata (W. & A.) Engl.	*Balsamodendron caudatum* W. & A.
Commiphora mukul (Hook ex Stocks) Engl.	*Balsamodendron mukul* Hook ex Stocks
Corchorus aestuans Linn. non Forsk.	*Corchorus acutangulus* Lamk.
Cordia dichotoma Forst. F.	*Cordia obliqua* Willd.
Crataeva unilocularis Ham.	*Crataeva roxburghii* Br.
Crypsis schoenoides (Linn.) Lamk.	*Heleochloa schoenoides* (Linn.) Host.
Cymbopogon coloratus (Nees) Stapf.	*Andropogon coloratus* Nees.
Cymbopogon jwarancusa (Jones) Schult.	*Andropogon jwarancusa* Jones
Cymbopogon nardus (Linn.) Rendle.	*Andropogon nardus* Linn.
Cymbopogon polyneuros (Steud.) Stapf.	*Andropogon polyneuros* Steud.
Dactyloctenium aegyptium (Desf.) Beauv.	*Eleusine aegyptiaca* Desf.
Dactyloctenium scindicum Boiss.	*Eleusine aristata* Ehrenb.
Dendrophthoe falcata (Linn. f.) Etting.	*Loranthus longiflorus* Desr.
Derris trifoliata Lour.	*Derris uliginosa* Benth.
Desmostachya bipinnata (Linn.) Stapf.	*Eragrostis cynosuroides* Beauv.
Dichanthium annulatum (Forsk.) Stapf.	*Andropogon annulatus* Forsk.
Dillenia aurea Sm.	*Dillenia pulcherrima* Kurz.
Diospyros peregrina (Gaertn.) Gurke.	*Diospyros embryopteris* Pers.
Diploknema butyracea (Roxb.) H. J. Lamb.	*Bassia butyracea* Roxb. *Madhuca butyracea* (Roxb.) Macbride.
Dipterocarpus alatus Roxb.	*Dipterocarpus incanus* Roxb.
Dipterocarpus gracillis Bl.	*Dipterocarpus turbinatus* var. *andamanica* King.
Dipterocarps grandiflorus Bl.	*Dipterocarpus griffithi* Miq.
Dolichandrone atrovirens (Henye ex Roth.) Sprague	*Dolichandrone crispa* Seem.
Dolichandrone spathacea (Linn f.) K. Schum.	*Dolichandrone rheedii* Seem.
Drypetes lancifolia (Hk. f.) Pax. & Hoffm.	*Cyclostemon lancifolius* Hook . f.
Drypetes sepiaria (W. & A.) Pax. & Hoffm.	*Hemicyclia sepiaria* W. & A.
Drypetes venusta (Wight) Pax. & Hoffm.	*Hemicyclia venusta* Thw.

APPENDIX D (ii)—*contd.*

Current name	Obsolete name
Duabanga grandiflora (Roxb.) Walp.	*Duabanga sonneratioides* Ham.
Eleusine compressa (Forsk.) Aschers. et. Schwf. ex Christensen	*Eleusine flagellifera* Nees.
Embelia tsjeriam-cottam (R. & S.) A.DC.	*Embelia robusta* C.B. Cl. non Roxb.
Emblica officinalis Gaertn.	*Phyllanthus emblica* Linn.
Endospermum chinense Benth.	*Endospermum malaccense*
Entada phaseoloides (L.) Merrill.	*Entada scandens* Benth.
Eragrostis interrupta (Lamk.) Beauv.	*Poa interrupta* Lamk.
Eragrostis unioloides (Retz.) Nees ex. Steud.	*Poa unioloides* Retz.
Eranthemum purpurascens Nees	*Daedalacanthus purpurascens* T. Anders.
Eremopogon foveolatus (Del.) Stapf.	*Andropogon foveolatus* Del.
Erianthus arundinaceus (Retz.) Jesweit	*Saccharum arundinaceum* Retz.
Erianthus munja (Roxb.) Jesweit.	*Saccharum munja* Roxb.
Erianthus ravennae (Linn.) P. Beauv.	*Erianthus elephantinus* Hook.f.
Erythrina variegata Linn. var. *orientalis* (Linn.) Merr.	*Erythrina indica* Lamk.
Eulalia hirtifolia (Hack.) Ktze.	*Pollinia hirtifolia* Hack.
Eulalia mollis (Griseb.) Ktze.	*Pollinia mollis* Hack.
Eulalia trispicata (Schult.) Henr.	*Pollinia argentea* Trin. *Eulalia argentea* Brongn.
Eulaliopsis binata (Retz.) C. E. Hubb	*Ischaemum angustifolium* Hack.
Eugenia formosa Wall.	*Jambosa formosa* Walp.
Eugenia kurzii Duthia.	*Jambosa kurzii*
Eugenia praecox Roxb.	*Jambosa praecox*
Eugenia ramosissima Wall.	*Jambosa ramosissima*
Euphoria longana Lamk.	*Nephelium longana* Camb.
Evodia lunu-ankenda (Gaertn.) Merr.	*Evodia roxburghiana* Benth.
Fagara budrunga Roxb.	*Zanthoxylum budrunga* DC. *Zanthoxylum rhetsa* D.C.
Feronia limonia (Linn.) Swingle	*Limonia acidissima* Linn.
Firmiana colorata (Roxb.) R. Br.	*Sterculia colorata* Roxb.
Flacourtia indica (Burm. f.) Merr.	*Flacourtia ramontchi* L' Herit. *Flacourtia sepiaria* Roxb.
Gardenia resinifera Roth.	*Gardenia lucida* Roxb.
Glinus lotoides Linn.	*Mollugo hirta* Thunb.
Grewia tenax (Forsk.) Fiori.	*Grewia populifolia* Vahl.
Gymnosporia spinosa (Forsk.) Fiori.	*Gymnosporia montana* Benth.
Gyrocarpus jacquinii Gaertn.	*Gyrocarpus americanus* auct. non Jacq.
Hedera nepalensis K. Koch.	*Hedera helix* auct. non Linn.
Hesperethusa crenulata (Roxb.) Roem.	*Limonia crenulata* Roxb.
Heteropogon contortus (Linn.) Beauv. ex. R. & S.	*Andropogon contortus* Linn.
Heterophragma quadriculare (Roxb.) K. Schum.	*Heterophragma roxburghii* A. DC.
Hopea utilis (Bedd.) Bole.	*Balanocarpus utilis* Bedd.
Hydnocarpus kurzii (King.) Warb.	*Taraktogenos kurzii* King.
Imperata cylindrica (Linn.) Beauv.	*Imperata arundinacea* Cyrill.
Ipomoea pes-caprae (Linn.) Sweet.	*Ipomoea biloba* Forsk.
Ixora arborea Roxb. ex Sm.	*Ixora parviflora* Vahl. non Lamk.

APPENDIX D (ii)—*contd.*

Current name	Obsolete name
Juniperus wallichiana Hk. f. ex Parl	*Juniperus pseudo-sabina* Hk. F. non Fisch. ex Mey.
Kandelia candel (Linn.) Druce.	*Kandelia rheedii* W. & A.
Kingiodendron pinatum (Roxb.) Harms.	*Hardwickin pinnata* Roxb.
Kurrimia indica (Bedd.) Gamble.	*Kurrimia bipartita* Laws.
Lagerstroemia speciosa (Linn.) Pers.	*Lagerstroemia flos-reginae* Retz.
Lannea coromandelica (Houtt.) Merr.	*Odinn wodier* Roxb. *Lannea grandis* (Denst.) Engler
Leea indica (Burm.) Merr.	*Leea sambucina* Willd.
Leptadenia pyrotechnica (Forsk.) Decne.	*Leptadenia spartium* Weight.
Lindenbergia indicn (Linn.) O. Ktze.	*Lindenbergia urticaefolia* Lebin.
Lithocarpus spicatus (Sm.) Rehd. & Wils.	*Pasania spicata* (Syn. *Quercus spicata* Sm).
Litsea glutinosa (Lour.) C. B. Robinson	*Litsea chinensis* Lam.
Litsea monopetala (Roxb.) Pers.	*Litsea polyantha* Juss.
Lyonia ovalifolia (Wall.) Drude.	*Andromedia ovalifolia* Wall. *Pieris ovalifolia* (Wall.) D. Don.
Madhuca indica Gmel.	*Bassia latifolia* Roxb. *Madhuca latifolia* (Roxb.) Macbride
Mahonia napaulensis DC.	*Berberis nepalensis* Spring. in part
Manilkara littoralis (Kurz.) Dub.	*Mimusops littoralis* Kurz.
Manilkara hexandra (Roxb.) Dub.	*Mimusops hexandra* Roxb.
Melanocenchris jacquemontii Jaub & Spach.	*Gracilea royleana* Hook . f.
Michelia doltsopa Buch-Ham. ex DC.	*Michelia excelsa* Bl. ex Wall.
Microstegium ciliatum (Trin.) A. Camus.	*Pollinin ciliata* Trin.
Miliusa tectona Hutch. ex Parkin son.	*Saccopetalum tectonum* (Hutch.) Chatterjee
Miliusa tomentosa (Roxb.) J. Sinclair	*Saccopetalum tomentosum* Hk. f. & Th.
Mitragyna parvifolia (Roxb.) Korth.	*Stephegyne parvifolia* Korth.
Mnesithea laevis (Retz.) Kunth	*Rcttboellia perforata* Roxb.
Moghania (Linn.) St. Hil. ex Jacks.	*Flemingia* Roxb. ex. Ait.
Moringa oleifera Lamk.	*Moringa pterygosperma* Gaertn.
Mucuna nigricans (Lour.) Steud.	*Mucuna imbricata* DC.
Mucuna prurita Hook	*Mucuna pruriens* Baker non DC.
Murdannia nudiflorum (Linn.) Brenan.	*Aneilema nudiflorum* R. Br.
Murraya paniculata (Linn.) Jack.	*Murraya exotica* Linn.
Myrica sapida Wall.	*Myrica nagi* Thunb.
Narenga porphyrocoma (Hance) Bor	*Saccharum narenga* Ham.
Neohouzeaua dullooa A. Camus.	*Teinostachyum dulllooa* Gamble.
Neyraudia arundinacea (L.) Henr.	*Triraphis madagascariensis* Hk. f.
Nyssa javanica (Bl.) Wang.	*Nyssa sessiliflora* Kh. f. & Th.
Ochlandra wightii (Munro) C.E.C. Fisher	*Ochlandra brandisii* Gamble.
Ochrosia oppositifolia (Lamk.) K. Schum.	*Ochrosia borbonica* Hk. f. non Gmel.
Ocimum americanum Linn.	*Ocimum canum* Sims.
Osyris wightiana Wall. ex Wight	*Osyris arborea* Wall. ex A. DC.
Ougeinia oojeinensis (Roxb.) Hochreut	*Ougeinia dalbergioides* Benth.
Palaquium ellipticum (Dalz.) Engler.	*Bassia elliptica* Dalz.
Pandanus tectorius Soland ex Parkinson	*Pandanus odoratissimus* Roxb.
Paspalidium flavidum (Retz.) A. Camus.	*Panicum flavidum* Retz.
Pergularia daemia (Forsk.) Chiov.	*Pergularia extensa* N.E. Br.
Perotis indica (Linn.) O. Ktze.	*Perotis latifolia* Ait.
Persea owdenii (Parker) Kostermans	*Alseodaphne owdenii* Parker

APPENDIX D (ii)—*contd.*

Current name	Obsolete name
Picea smithiana (Wall). Boiss.	*Picea morinda* Link.
Picea spinulosa (Griff.) Henry	*Picea morindoides* Rehd.
Pinus insularis Endl.	*Pinus khasya* Royle ex Parl.
Pinus roxburghii Sargent	*Pinus longifolia* Roxb.
Pinus wallichiana A. B. Jackson	*Pinus excelsa* Wall.
Planchonia valida Bl.	*Planchonia andamanica* King.
Pleiospermium alatum (W. & A.) Swingle	*Limonia alata* W. & A.
Podophyllum hexandrum Royle	*Podophyllum emodi* Wall.
Pogonatherum paniceum (Lamk.) Hack.	*Pogonatherum saccharoideum* Beauv.
Pongamia pinnata (Linn.) Pierre	*Pongamia glabra* Vent.
Protium serratum (Wall. ex. Cobler) Engl.	*Bursera serrata* Wall. ex Cobler
Prunus cornuta Steud.	*Prunus padus* (non Linn.) Hk. f.
Pseudopogonatherum contortum (Brongn.) A. Camus	*Puliculum articulatum* (Trin.) Stapf ex Haines
Pseuduvaria prainii (King) Merr.	*Mitrephora prainii* King
Pteridium aquilinum Kuhn	*Pteris aquilina* Linn.
Pterocymbium tinctorium (Blanco) Merr.	*Sterculia campanulata* Wall. ex Masters.
Pterygota alata (Roxb.) R. Br.	*Sterculia alata* Roxb.
Radermachera xylocarpa (Roxb.) K. Schum.	*Stereospermum xylocarpum* Benth. & Hk. f.
Rauwolfia spp. Linn.	*Ophioxylon* spp. Wight
Rhizophora candelaria DC.	*Rhizophora conjugata* Kurz. non Linn.
Rhododendron hypenanthum Balf.	*Rhododendron anthopogon* Don.
Rinorea bengalensis (Wall.) O. Ktze.	*Alsodeia bengalensis* Wall.
Salmalia insignis (Wall.) Schott. & Endl.	*Bombax insigne* Wall.
Salmalia malabarica (DC.) Schott. & Endl.	*Bombax malabaricum* DC.
Sapindus emarginatus Vahl.	*Sapindus trifoliatus* Hiern.
Sarcostemma acidum (Roxb.) Voigt.	*Sarcostemma brevistigma* W. & A.
Scaevola frutescens (Mill.) Kranse	*Scaevola koenigii* Vahl.
Schleichera oleosa (Lour.) Oken	*Schleichera trijuga* Willd.
Sclerostachya fusca (Roxb.) A. Camus.	*Saccharum fuscum* Roxb.
Scutia myrtina (Burm.) Kurz.	*Scutia indica* Brongn.
Sehima nervosum (Rottl.) Stapf.	*Ischaemum laxum* R. Br.
Sehima notana (Hack.) A. Camus.	*Ischaemum notanum* Hack.
Sehima sulcatum (Hack.) A. Camus.	*Ischaemum sulcatum* Hack.
Securinega leucophyrus (Willd.) M. Arg.	*Flueggea leucopyros* (Koen.) Willd.
Securinega virosa (Roxb. ex Willd.) Pax & Hoffm.	*Flueggea microcarpa* Bl.
Setaria palmifolia (Koenig) Stapf.	*Panicum plicatum* Willd. (non Lamk.)
Sloanea assamica Rehder & Wilson	*Echinocarpus assamicus* Benth.
Sloanea dasycarpa (Benth.) Hemsl.	*Echinocarpus dasycarpa* Benth.
Smilax zeylanica Linn.	*Smilax macrophylla* Roxb.
Sonneratia caseolaris (Linn.) Engler	*Sonneratia acida* Linn. f.
Sorbus foliolosa (Wall.) Spach.	*Pyrus foliolosa* Wall.
Sorghum halepense (Linn.) Pers.	*Andropogon halepensis* Brot.
Spondias pinnata (Linn. f.) Kurz.	*Spondias mangifera* Willd.
Sporobolus elongatus R. Br.	*Sporobolus indicus* Hook. f. non R. Br.
Sporobolus marginatus Hochst. ex Rich.	*Sporobolus arabicus* Boiss. *Sporobolus pallidus* (Nees) Boiss.

APPENDIX D (ii)—*concld.*

Current name	Obsolete name
Stereospermum personatum (Hassk.) Chatt.	*Stereospermum chelonoides* auct. non *nisipartim* A.DC
Symplocos laurina (Retz.) Wall. ex G. Don.	*Symplocos spicata* Roxb.
Symingtonia populnea (R. Br.) Van Steenis	*Bucklandia populnea* R. Br. ex Griff.
Syzygium caryophyllatum (Linn.) Alston	*Eugenia caryophyllaea* Wt.
Syzygium cerasoideum (Roxb.) Raizada	*Eugenia cerasoides* Roxb. *Eugenia operculata*
Syzygium cumini (Linn.) Skeels	*Eugenia jambolana* Lamk. *Syzygium jambolanum* DC.
Tamarix aphylla (Linn.) Karst.	*Tamarix articulata* Vahl.
Tamarix troupii Hole	*Tamarix gallica* auct non Linn.
Tecomella undulata (Smith) Seem	*Tecoma undulata* G. Don.
Ternstroemia gymnanthera (W. & A. Sprague)	*Ternstroemia japonica* auct. non Linn.
Thamnocalamus aristatus E. G. Camus	*Arundinaria aristata* Gamble.
Thamnocalamus falconeri Hook. f.	*Arundinaria falconeri* (Hook. f.) Benth. et Hook.
Thamnocalamus spathiflorus (Trin.) Munro	*Arundinaria spathiflora* Trin.
Themeda anathera (Nees ex Steud.) Hack.	*Anthistiria anathera* Nees ex Steud.
Themeda arundinacea (Roxb.) Ridley	*Anthistiria arundinacea* Roxb. *Anthistiria gigantea* Cav.
Themeda quadrivalvis (Linn.) O. Ktze.	*Anthistiria ciliata* Linn. f. *Themeda ciliata* (Linn. f.) Hack.
Themeda triandra Forsk.	*Anthistiria imberbis* Retz.
Thysanolaena maxima (Roxb.) O. Ktze.	*Thysanolaena agrostis* Nees. *Agrostis maxima* Roxb.
Tiliacora acuminata (Lamk.) Miers	*Tiliacora racemosa* Colebr.
Toddalia asiatica (Linn.) Lamk.	*Toddalia aculeata* Pers.
Tragus biflorus (Roxb.) Schult.	*Tragus racemosus* Hook. f.
Tsuga dumosa (D. Don) Eichler	*Tsuga brunoniana* Carr.
Turpinia cochinchinensis (Lour.) Merr.	*Turpinia nepalensis* W. & A.
Urochloa panicoides Beauv.	*Urochloa helopus* Stapf.
Vallaris solanacea (Roth.) O. Ktze.	*Vallaris heynei* Spreng.
Vetiveria zizanioides (Linn.) Nash.	*Andropogon muricatus* Retz.
Vitex quinata (Lour.) F. N. Williams	*Vitex heterophylla* Roxb.
Woodfordia fruticosa (Linn.) Kurz.	*Woodfordia floribunda* Salisb.
Xantolis tomentosa (Roxb.) Rafin.	*Sideroxylon tomentosum* Roxb.
Xylocarpus granatum Koenig.	*Carapa obovata* Bl.
Xylocarpus moluccensis (Lam.) Roem.	*Carapa moluccensis* Lam.
Zizyphus mauratiana Lamk.	*Zizyphus jujuba* Lamk. non Linn.
Zizyphus nummularia (Burm f.) W. & A.	*Zizyphus rotundifolia* Lamk.

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The following abbreviations are used:—

Andamans	An
Andhra Pradesh	A.P.
Assam	As
Bihar	Bi
Delhi	D
Gujarat	Gj
Himachal Pradesh	H.P.
Jammu & Kashmir	J. K.
Kerala	Kr
Madhya Pradesh	M. P.
Madras	Md
Maharashtra	Mh
Manipur	Mn
Mysore	My
Nagaland	N.L.
Orissa	Or
Punjab	Pj
Rajasthan	Rj
Uttar Pradesh	U. P.
West Bengal	W. B.

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Appendix on the methods of studying forest types will be published separately.